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SOCIAL AND ECONOMIC IMPACT OF THE USE OF SLAG LAYERS IN RAILWAY FOUNDATIONS

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1. EXECUTIVE SUMMARY

This document consists of the analysis of the social and economic impacts produced by the activities and results of the LIFE GAIN project carried out by COMSA.

The project tries to enhance the valorisation of an industrial waste product, such as the black slag derived from the steel production, using it in the railway foundations layers. As a result it will improve the mechanical properties of the track and clearly reduce the environmental impact of the track maintenance, renewal and construction.

The LIFE GAIN is carried out in a context where the eco-friendly activities are promoted by the European Union since it is important to reduce the waste production and the social and environmental impact that it has. With this objective, this project has been presented to solve the problem of Steel Furnace Slag (SFS), which actually is an important waste product in the whole Europe.

With this analysis we have tried to conclude which is the impact of the project on the society and to evaluate the social and economic impacts that the project actions will have in the influence zone of the activities. Likewise, we also try to gain knowledge about the social opinion of a project like that, since nowadays it's important to include the population feedback in the companies' actions and strategies to improve their results and turnover.

In the first place, with the aim to make clear the objectives and the previous research and activities of the LIFE GAIN project, a brief introduction has been done. This introduction consists of the description of the context and objectives of the project and the state of the art of the SFS. Furthermore, the properties and the previous tests done in the investigation of the valorised product (SFS-RAIL) are detailed in this point to have an idea about the commercialized product.

Secondly, it is presented the diagnosis of the studied area, which describes and characterizes different topics of the project's influence zone. In this chapter we have analysed the territory and demography of the area since it is an important issue to quantify and evaluate the possible impact of the project in the society and the surrounding environment. A delimitation of the territory influenced by the project has been necessary to analyse the local impact. Moreover, the description of the structure, distribution and evolution of the population affected has been done to get a better characterization of the region inhabitants. In addition, we have analysed the active population that we could find in the area, which will be a priori the most affected group by the generation of economic activity because of the project actions.

In addition, the local business network has been studied in order to quantify the contribution of each industrial sector in the economic activity of the region and bear out the importance of the siderurgy sector in the two areas of analysis. In the same way, the labour mobility patterns of the population in the influence zone are analysed to identify the main poles of attraction. It is important to characterize the situation of the industry, since the new industrial activity created by the project could modify this flow of daily trips or enhance the trends if it is in line with them.

Furthermore, in this chapter we have carried out an anonymous survey to the population of the region to know their opinion about the project analysed since it is undeniable the relation between the activity of a company and the society. Nowadays, it's important to establish a dynamic interaction with the different social agents, where its expectations and opinions are included in the company strategies. The information flows resulting from this new dynamics are very precious actives for the company since it will provide a higher sensitivity with the surrounding area, helping to anticipate risks and to get more profit from the opportunities that may arise.

To complete this section, a more detailed analysis of the siderurgy industry of the project and field test influence zone has been carried out. During this analysis we have characterised and delimited the siderurgy sector of Asturias and Catalonia and its economic contribution in the whole country concluding that both of them are two of the most important Spanish siderurgy areas. The waste production of the sector and the waste recycling techniques are also described since it will be necessary to quantify and evaluate the innovations introduced by the project and how it will affect to the amount of waste landfilled and to the different uses that black slag have in the present.

Continuing with the scheme of the analysis, the different impacts of the project and its consequences in the topics explained above have been described in the next chapter. We have summarized the main impacts in different topics such as the impact of the foreseen investment, the impact of the increase of steel slag recycling, the impact of the decrease of industrial waste, the impact of the reduction of quarries activity and the impact of the increase of jobs. A relation and the consequences in the topics of the previous chapters have been established for the correct evaluation of the impacts.

To finish with the analysis, all the conclusions extracted from the different chapters of the evaluation of the project have been presented summarized in a list. Some positive results derived from the implementation of the project have been identified, which allow us to conclude that this project is interesting in both social and economic terms.

2. INTRODUCTION: LIFE+GAIN PROJECT

The goal of this research is to identify and evaluate the social and economic effects at local level of the envisaged activities of the project “LIFE+GAIN: Slag layers in railway foundations” which is carried out by COMSA and ADEC GLOBAL.

COMSA is a construction company, which undertakes any kind of civil works, with railways as its core business. It's one of the most important companies of the country and it has a strong presence in other European member states and in other international markets. COMSA is aware of the importance of constructing sustainable infrastructures trying to reduce its environmental impact. Nowadays the company is carrying out different projects to develop new durable and environmentally friendly construction materials, most of them including waste material giving them a new valorisation use.

On the other hand, the company ADEC GLOBAL is the only valorisation plant in Catalonia having an environmental license for the valorisation of Electric Arc Furnace Slag (EAFS). The company manages 100% of the EAFS annual production of the Spanish steel-producing company CELSA, which ascends to a maximum of 360,000 tonnes/year, from which 280,000 tonnes/year are black slag. This amount is limited by the plant capacity and one of the principal problems is that in Spain there is not enough demand of EAFS aggregates to satisfy such amount of slag, generating a stock of 350,000 tonnes in just 3 years.

In this assessment we will distinguish different measurable impacts such as business opportunities, local business competitiveness or a better standard of living due to increased access to employment or the benefits of the solution proposed.

Generally speaking, the aim of the GAIN project is to extend the market of an industrial waste product by identifying a new field of valorisation, which shows good environmental and economic returns. More specifically, the project is focus in the development of a new alternative of valorisation for the EAFS, which is a subtype of SFS. The innovation that COMSA and ADEC GLOBAL propose consists of using black slag (subtype of EAFS) as raw material to produce recycled aggregate to be used in the sub-ballast and subgrade rail track foundation layers. This product is named SFS-Rail and it could be commercialized in the next years depending on the results of the project.

Track bed layers (which usually refers to ballast and blanket layers) and form layers (meaning the upper part of the subgrade aimed at providing the required characteristics to the platform) play a key role in track behaviour with respect to track support stiffness, maintenance of track geometry and drainage, among others. It is well known that many problems related to track geometry come from a deficient condition of track bed layers. Therefore, if resilience and stability of railway infrastructure are sought, high quality aggregates for track bed and form layers should be employed.

Traditionally, materials employed in track bed and form layers are natural aggregates that derive from quarries. In this sense, new challenges have arisen in the time being as high quality aggregates - as a natural resource they are - have started to be scarce and not always an available material. As a result, in some specific locations and projects, long transport routes must be done in order to get the right material, which results in an

increase of not only cost, but of the environmental burdens associated to track construction.

This occurs in a context where EC policies have increased its strictness in environmental issues, whereas sustainable, durable and cost-efficient solutions are each time more encouraged. For this reason, the appearance of a new recycled material with enhanced mechanical properties seems to align perfectly with the future development of track infrastructure, where best LCC/LCA solutions will prevail.

Within the framework of the GAIN project (funded by EC LIFE+ programme), a new recycled aggregate is being developed not only to fulfil all the technical requirements of national and European norms regulating their employment in track bed and form layers, but to go beyond them and offer excellent mechanical properties. The aggregates in question are obtained by the valorisation of (black) EAFS.

The production of black slag represent an important amount of the industrial waste around the European Union and due to its characteristics it can be profitable for other uses such as additive for the concrete or this proposed in the GAIN project. It is estimated that between 8.5 and 14.5 million tonnes/year [1] of black slag are produced by the European steel producers.

The most important expected result of the project is to demonstrate that SFS-Rail represents an innovative, sustainable and eco-friendly alternative to natural aggregates and in order to achieve this, it is important to asses which will be the possible social and economic impact. Here in this analysis we are going to consider just the local impact understood as the impact caused by activities like the construction of the field tests of the project and the process of the valorisation of the black slag, obtained from CELSA, where the adaptations of the existing valorisation plant will be necessary to produce SFS-Rail.

2.1. State of the art

The main application of Steel Furnace Slag (SFS) in Europe is for road construction (48%) and only a 13% of the total amount of steel slag generated is sent to landfills. The use of ferrous slag in railway applications is not as common as in road construction and the only experiences found were in USA, Brazil, Canada and India.

According to the Minerals Yearbook-2000 [2] of the US Geological Survey (USGS) the use of the black furnace slag in the construction field started in the early 1900s, mainly used in railroad ballast, Portland cement aggregate and aggregate for road construction. It wasn't till 1975 when the railroad ballast was de 2nd most important use of black furnace slag, with 3.66 million tons (18%), and the 3rd most important use of SFS, with 0.56 million tons (8.4%) while road applications remained in the first place in both cases.

In 1999 a significant rise in the percentage of SFS as railroad ballast was observed, with 1.2 million tons (19.4%), but according to the latest Mineral Yearbook published by USGS [3] in 2011 no SFS was intended for this application where the road base and surfaces continued being the primary application with the 46.8% of the production. This evolution is logically related to the development of the railway in US.

Regarding the use of SFS as railroad aggregates in Europe, no evidence has been detected. This fact made the GAIN project more interesting for the railway development in the European Union giving us lots of new possibilities in this sector.

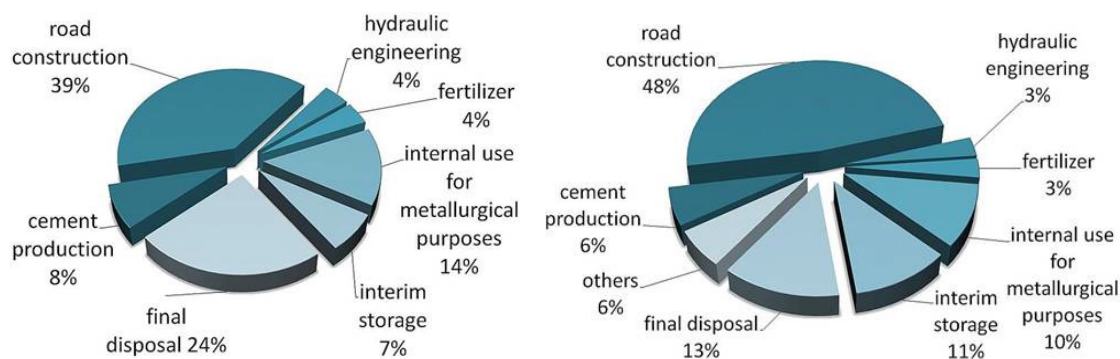


Figure 2.1. Use of steel slag in 2000 (16.8 million tonnes) and 2010 (22.3 million tonnes). Source: EUROSLAG.

As is shown in Figure 2.1 white and black slag has too many different applications and due to its characteristics it can be a profitable product in some sectors.

In Spain, the white slag, which is not in the scope of this project, could be used as a soil stabilizer and material for embankments. Furthermore, in the edification and public works this kind of slag is used as a substitution product of the loam in the cement although its application is limited. The percentage of MgO cannot be higher than 5% because of its expansion problems associated.

Talking now about the black slag, the principal use is in road construction but we have to take care with the risk of expansion and swelling that it produces, and limit its use when necessary. Is usual to find it combined with other kind of aggregates to make its application easy, but the slag should never be used in cement stabilized layers or prefabricated elements that prevent a possible expansion.

In the cement industry the black slag is used as supply of iron and silicon for the clinker or as aggregate for the concrete. This application is not limited in environmental or mechanical terms but it is recommended that it does not overcome a 40% to obtain the best final properties of the product. Regarding its use in the concrete, it is allowed to substitute the 100% of the large aggregate fraction and up to a 30% of the fines.

Slag aggregates must comply with the existing norms regulating the use of aggregates in subgrade and subballast layers. At this moment, it can only be found a specific railway standard, at a European level, for ballast aggregates (EN 13450:2013) but not for the subballast or subgrade aggregates. There is a more general standard regulating the aggregates for civil applications (EN 13242:2013), which includes some specifications regarding the use of steel slag as aggregate for foundation layers. The standard states that slag aggregates can be considered stable if the expansion (according to EN 1744-1) does not exceed the certain maximum values, depending on the application or its final use.

Some environmental considerations have been taken into account for the use of slag. In Spain, the requirements are collected in the law 22/2011 of waste and contaminated soils, which specifies that the measures applied will be in line with the European waste list, particularly where in the chapter 10 in the codes 10 02 01 and 10 02 02.

Slag aggregates should comply with additional norms compared to aggregates obtained from quarries, given that in many countries there are still treated, as waste and specific tests must be carried out in order to allow them being recycled and used as a product. Classification of slag by European legislation has evolved during the last years as a

result of 25 years of discussion on this issue. How slag aggregates are classified according EU legislation –waste, product or by-product-, has a direct effect on the strictness of the requirements they have to fulfil. According to revised Waste Framework Directive 2008/98/CE, slag can be considered as by-product or even as a product.

At a national level, there are several countries in Europe such as Germany that have developed specific standards for regulating the use of steel slag as subballast and other civil applications. Nevertheless, there is a lack of these norms in some other European countries such as Spain or Portugal.

2.2. Description of SFS-RAIL

Steel furnace slag is produced during the conversion of hot metal to crude steel in a basic oxygen furnace or during the melting of scrap in an electric arc furnace. The composition of slag varies upon the type of furnace and charge, the desired grade of steel purity and the furnace operation conditions. Its real production is unavailable since it is not a mined material, so the production of EAFS is strongly linked to steel production.

Not all the production of EAFS is valid to produce SFS-Rail, approximately the 25% of the production are white slag, which cannot be used as an aggregate due to its chemical composition.

The SFS-Rail is a new construction material proposed by COMSA that could be used in the railway tracks and the steel furnace slag (black slag) are the principal waste material needed to product it. SFS-Rail is manufactured by crushing mechanical stabilization of black slag in a valorisation plant, where different size of granulates can be obtained. The mixture of this granulates makes it possible to obtain any specific granulometry, which results very useful to fulfil the requirement of the European railway regulations.



Figure 2.2. Different granulometries of EAFS aggregates.

The use of SFS-Rail in the railway tracks have different positive effect, on the one hand it is a convenient and sustainable alternative to natural aggregates that allows us reducing the use of it in railway construction, which means that less material will be extracted from quarries turning into a reduction of the environmental impact, with the subsequent consequences:

- Reduction of the anthropomorphic impact on nature
- Reduction of deforestation
- Reduction of the impact on vegetation and fauna

- Reduction of the hydrological impact
- Reduction of the frequency and intensity of transport
- Reduction of the CO₂-emissions
- Reduction of the energy consumption

On the other hand, it will produce a reduction of the transport needs associated to railway aggregates by placing new valorisation plants next to the steel furnaces, which turns into fuel saving and reduction of the CO₂-emissions.

Not all the quarries fulfil the technical requirements demanded by railway regulation to produce aggregates that could be use as ballast. In addition, in Catalonia just 5 of the 36 existing quarries are homologated by ADIF to produce railway ballast and actually only 2 are supplying material when it is necessary. This situation results in scattered location of quarries relative to most work-sites, which causes long transport distances. Therefore, it would be a good chance for the SFS-Rail since it will be more accessible to work-side than natural aggregates.

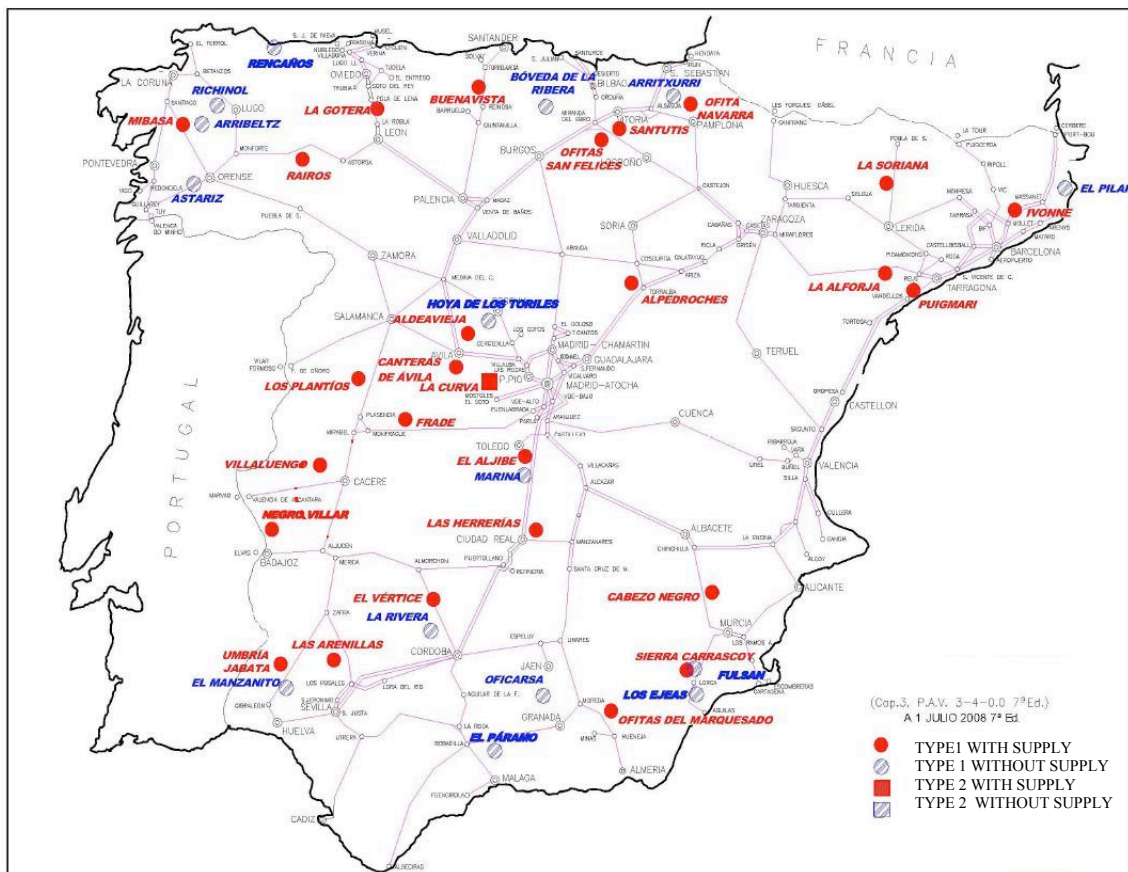


Figure 2.3 Spanish quarries with ballast supplying. Source: ADIF [4].

One of the main advantages of SFS-Rail aggregates are their mechanical properties. They can offer high resistance to abrasion whilst offering a competitive price in comparison to conventional aggregates. The use of SFS-Rail allows an increase of track lateral stability due mainly to:

- A better interlocking of particles as a consequence of the sharp corners and rough, pitted surfaces

- To the heavier weight of aggregates. As a result, track using SFS-Rail is more resistant to lateral track movements in tight curves.

Furthermore, SFS-Rail provides a better drainage because of its high percentage of void space, its cleanliness and its resistance to degradation. It contains no organic substances and, given its chemical composition, it avoids the appearance and growth of unwanted vegetation. Finally, SFS-Rail aggregates are highly resistant to degradation by changing climate conditions, such as wetting-drying cycles, freezing-thawing cycles, temperature changes and chemical attacks.

The difference in sale price between natural aggregates and EAFS aggregates increase with the hardness required. So the savings will be higher when EAFS substitute hard natural aggregates, such as the railway ones. Knowing this we can conclude that the use of SFS-RAIL will reduce the material cost of railway aggregates, which could result in important savings if this construction method would be applied along all railway lines during the construction of new track or its renewal. This effect could also be noticed in the field test proposed in the project, but of course in a less significant way due to the length of the sections.

Additionally, using SFS-Rail we will produce a reduction in the amount of final disposal and storage of black slag. Although landfill disposal of steel furnace slag has been incredibly diminished during the last decades, the final deposit rate is still very high, partially due to the economic crisis affecting the civil engineering, which reduces considerably the activity of the sector. For this reason is important to give new valorisation uses to that material.

Even though it is not the aim of this research, another important aspect of this innovative application of the slag is that the procedures implemented to produce SFS-Rail will be easily transferable to other European countries. This fact means that if the results of this project at a local level will be good enough, the valorisation solution proposed could be replicable in the whole Europe, achieving an important impact in economical, social and environmental terms.

2.3. Research on SFS-RAIL properties

COMSA and ADEC GLOBAL had already developed plenty of research on black slag before the conception of SFS-Rail. Although their previous work was related to other applications than railway aggregates (mainly road construction and concrete), they actually have an extensive knowledge about the properties and performance of black slag, which is also useful for its implementation in railway infrastructure.

The research done up to now of this innovative material have been carried out during two years with the objective of proving that black slag granulates fulfilled the requirements of the Spanish standards relative to the aggregates for sub-ballast and sub-grade layers. These laboratory tests showed us that the material fulfils all the specifications fixed in the standards that regulate the valorisations of ferrous slag and that the mechanical properties of it overpass the performance of natural aggregates.

All the benefits aforementioned are underpinned by the extensive campaign of laboratory tests carried out. In this way, the Los Angeles test (LA), which measures the abrasion resistance of the aggregates, showed a value of around 15-20 for SFS-Rail,

which compares favourably with good hard rocks and most standards. This feature is also confirmed by the results of the Micro-Deval (MD) test, which resulted below 20, in compliance with the Spanish norm, and the Polished Stone Value (PSV), which resulted between 57 and 65, being within the “High Performance” category, whereas it is difficult and expensive to obtain a natural rock with such characteristics that offers a high PSV.

Other tests indicate that SFS-Rail offers 100% of fracture faces, which guarantees the good interlocking between particles, an accelerated expansiveness according to UNE-EN 1744-1 of 0.3% after 168 hours, and a California Bearing Ratio (CBR) above 100, which is considerably higher than the obtained value using conventional aggregates.

The chemical composition of the EAFS aggregates have also been tested, highlighting the leaching test carried out to quantify the mobility of the chemical species (pollutant or not) contained in the SFS-Rail aggregates. The analysis criteria to classify SFS-Rail as inert or hazardous consist of a list of maximum concentration values for each chemical substance. The values of these thresholds may vary depending on the standard. In Catalonia, the “Decree 32/2009” establishes the limit values. All the leaching tests carried out complied with these values.

A Life Cycle Assessment (LCA) has been performed to evaluate the SFS-Rail environmental performance. The most relevant impact assessment categories considered have been the GWP (Global Warming Potential), AP (Acidification Potential), EP (Eutrophication Potential) and HTP (Human Toxicity Potential), which show how SFS-Rail reduces 35% in average the environmental impact of conventional aggregates, varying from 10% reduction for EP and 65% for HTP.

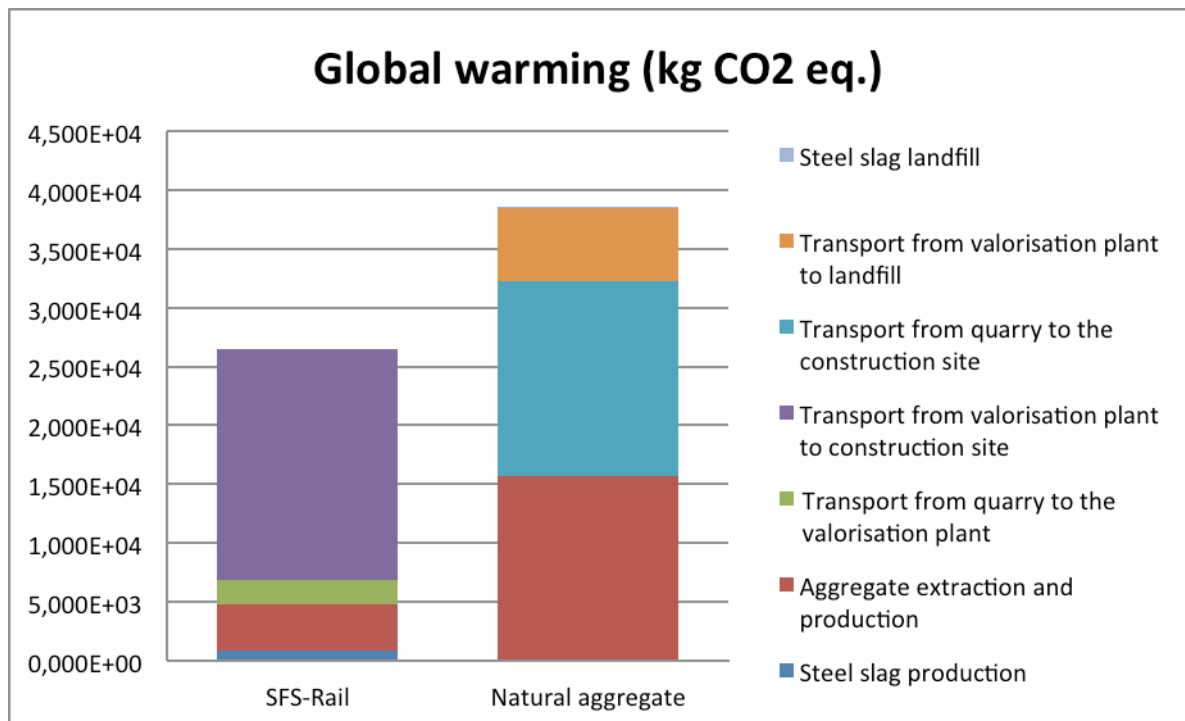


Figure 2.4. Environmental benefits of SFS-Rail in global warming.

In the figure above we could see the LCA corresponding to the global warming factor and the results are presented in kg of CO₂ equivalent. It is important to notice that the

impact of this factor is reduced a 30%, where the transport cost are reduced but not is the most important advantage. The reduction achieved is namely due to the impact on the aggregate extraction and production, improving the negative effect of this activity in the environment and the quality of life of the people around the quarries and landfills.

Consequently SFS-Rail will improve the mechanical performance of the railway track allowing to reduce the maintenance costs but it hardly increases the lifespan of the track due to the other limiting materials.

After the laboratory studies with encouraging results in the behaviour of the SFS-Rail, COMSA has recently started up the next step of the project that consists on carrying out some field tests. The tests are distributed in different sections of the railway track in Castellbisbal and Gijón in order to check the technical feasibility and the mechanical properties of the SFS-RAIL in a real situation, submitting the material to the railway loads of passenger and freight traffic. This field tests also will be analysed to take into account the possible economic local effects and the social acceptance of it.

The first field test placed in “El Puerto del Musel” in Gijón consists in three sections of 30 meters length:

- A 30 m long section with the subballast layer made of SFS-Rail
- A 30 m long section with the subballast and subgrade layers made of SFS-Rail
- A 30 m long section with conventional aggregates

The harbour had low traffic during week days and high traffic during the weekends, being directly proportional to the traffic arriving by ship to the harbour. Thus, during week days, it was enough to leave one track open for the passage of traffic. This track was, of course, the main track, while the rest of the tracks (which are derived from the main one) could be possessed for the renewal works. Hence, it was possible to work during working days during the day, with a permanent track possession, making this emplacement ideal for the field tests.

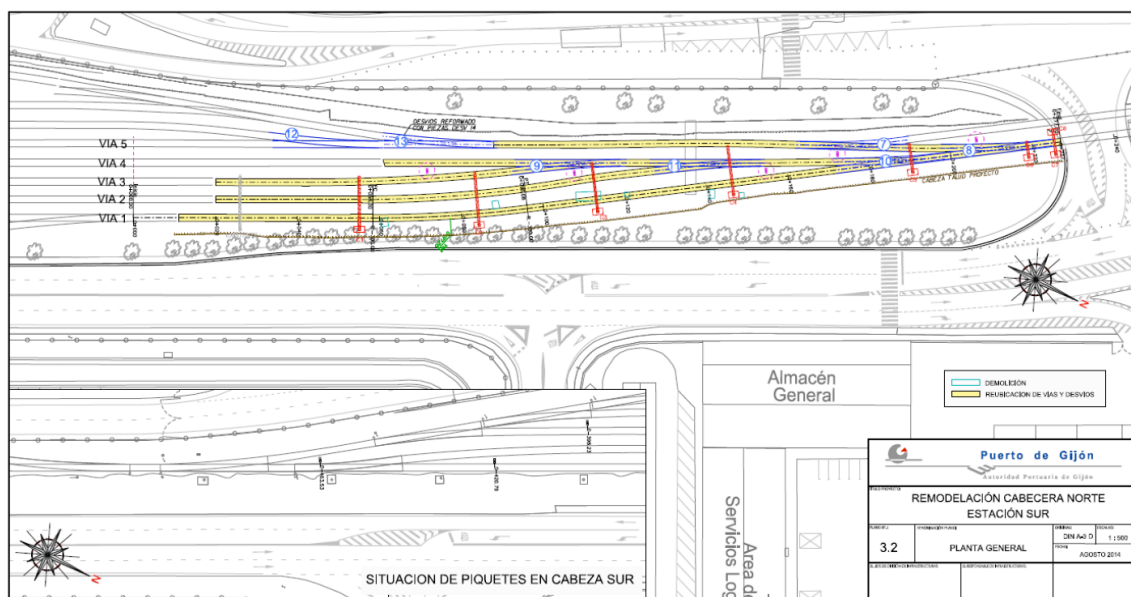


Figure 2.5. Layout of the track renewal of “El Puerto del Musel” (Gijón).



Figure 2.6. Construction of the first field test in Gijón.

In the Figure 2.5 is shown the general scheme of the track renewal works, where is possible to see the track distribution that allow us to work during the day, while in the Figure 2.6, is presented the detail of the different construction steps of the work in order to facilitate the comprehension of the field test structure.

The location of the second field test has been chosen as a result of a previous study of different places in Catalonia. This emplacement is excellent because it suits all the project demands, given that there is enough track possessions time, there is a wide access for the machinery, an extense zone by the track that have been used as storage area and the most important, it is near from ADEC GLOBAL's valorisation plant and, hence, minimizes the SFS-Rail transport and associated impact.

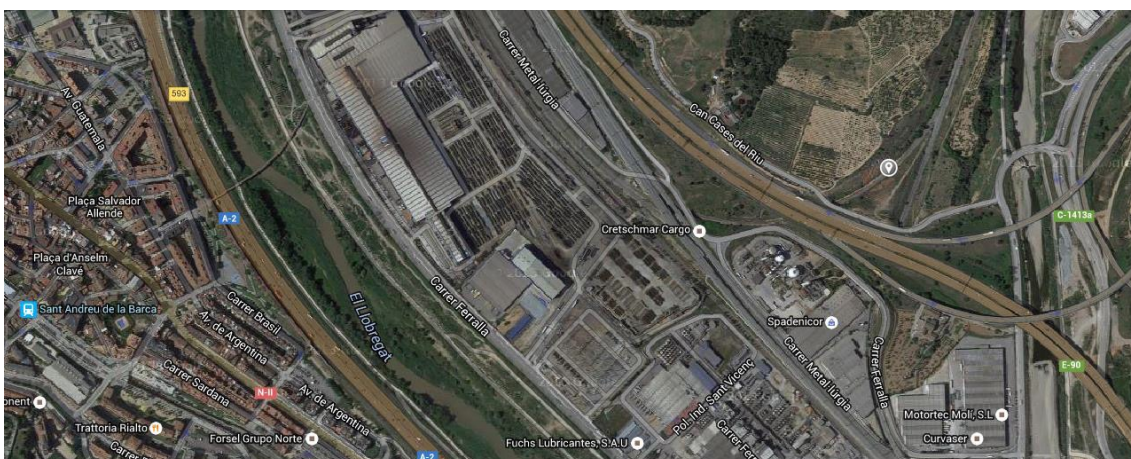


Figure 2.7. Location of the second field test in Castellbisbal.

The field test consist on a three sections of 50m length constructed in different ways in order to check the benefits of placing the slag layers in one or other position:

- A 50m long section with the existing conventional aggregates (control section).
- A 50m long section with the sub-ballast layer made of SFS-Rail and the subgrade layer with the existing conventional aggregates.
- A 50m long section with both the sub-ballast and subgrade layers made of SFS-Rail.

The control section plays an important role in the test to evaluate how the changes proposed in the tracks affect its response respect the original one. This section has been divided into two zones: one at each end of the field test.

In the figure below is shown the construction process of the field test and how the monitoring devices are place to measure the different parameters needed.



Figure 2.8. Construction of the second field test.

3. INITIAL SITUATION: DIAGNOSIS OF THE STUDIED AREA

In this part, we will proceed with the study of the territory and the population that could be affected with the economic and social impacts of the valorisations of the slag and the field tests. Given the disparity of the location of the field tests (Castellbisbal and Gijón), two areas have been considered: Catalonia and Asturias.

3.1. Territory and demography

3.1.1. Delimitation of the territory studied

In the obtention of SFS-RAIL there are two important actors: CELSA, placed in Castellbisbal, who is responsible for the production of the black slag waste, and the other one is Adec Global, placed in Vallirana, who is responsible for the valorisation of the waste product.

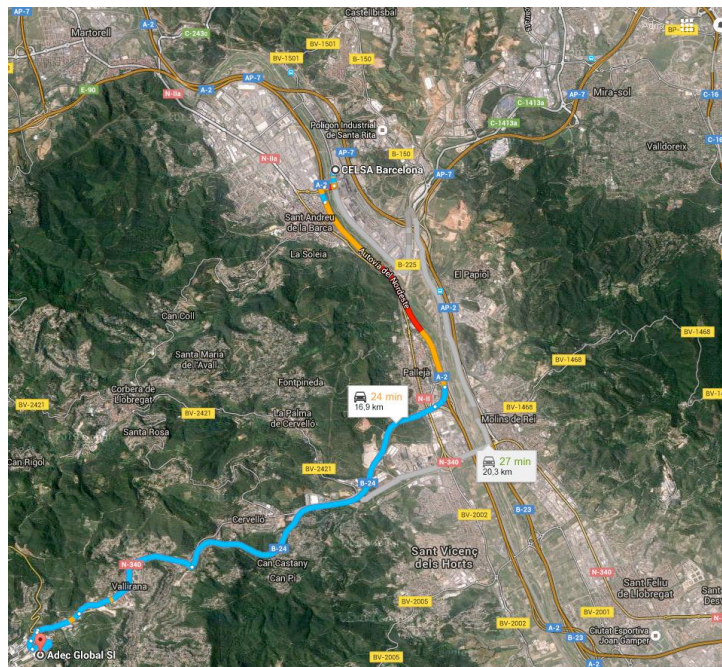


Figure 3.1.Transport connection between CELSA and ADEC GLOBAL.

Castellbisbal is a municipality placed in the region of Vallès Occidental, which also borders with the region of Baix Llobregat, where we could find the municipality of Vallirana. In order to proceed with the territory and demography study, the situation of the two main companies have been taking in account, concluding that the economical activity of the siderurgy industry and its workers have influence in the nearby municipalities such as Rubí, Sant Cugat, and the Central and Northern sector of region of Baix Llobregat.

Castellbisbal borders with the most important municipalities of Baix Llobregat in terms of demography, and a high percentage of this population is working in the industrial sector of Castellbisbal. On the other hand, talking about the region of Vallès Occidental,

the principal economic poles are Sabadell and Terrassa, and the people of that region tends to move more in that direction or to Barcelona for their jobs.

For that reason, the Baix Llobregat and the municipalities of Castellbisbal, Rubí and Sant Cugat are selected as the influence zone in Catalonia with regards to this study.

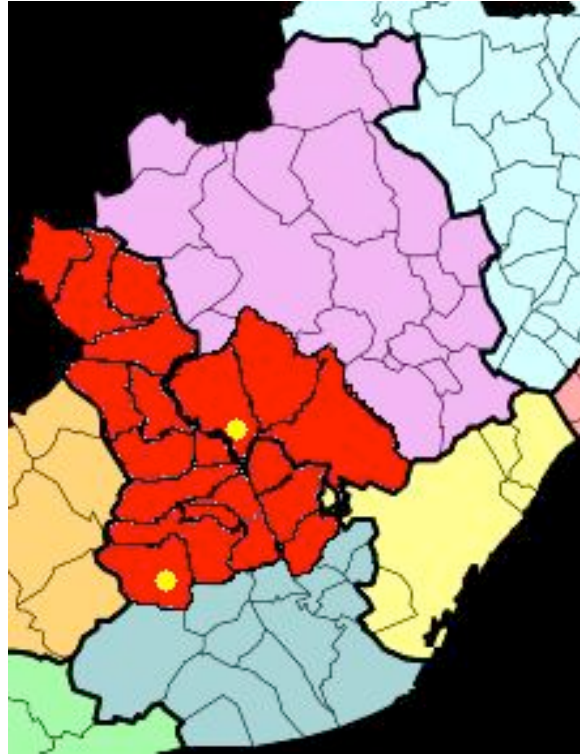


Figure 3.2. Delimitation of the catalan influence zone.

There is another important action in the GAIN project that we have to take into account to define the area affected by the project since one of the field tests is placed in the North of the country, more specifically in Gijón. It would be necessary to include this city and the surrounding territory in the analysis of the project impact.

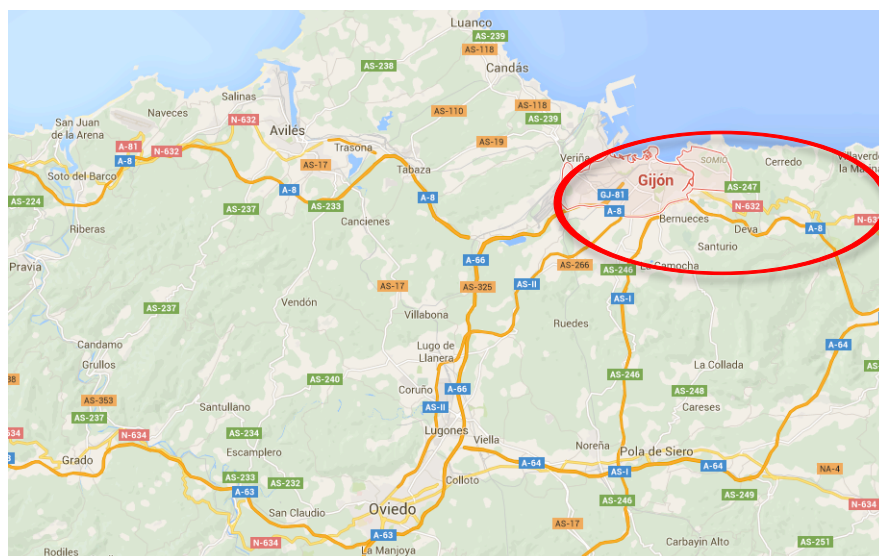


Figure 3.3. Delimitation of the territory in Asturias, Gijón.

Baix Llobregat

The extension of Baix Llobregat is parallel to the Llobregat river, from the Montserrat Mountain to the delta in the Mediterranean Sea. The region borders in the North with the Bages and Vallès Occidental, the regions of the Anoia, Garraf and Alt Penedès are placed in the West side, while in the East side one finds the Barcelonès.

The territorial division of the region has changed during the last century. The last modification took place in 1998, when the region was finally divided in 30 municipalities placing the capital in the town of Sant Feliu de Llobregat.



Figure 3.4. Situation of Baix Llobregat and Vallès Occidental in Catalonia.

In the region of Baix Llobregat two different sectors could be found. On the one hand, the centre of the region and the delta, which represents the most affected zone due to the economical and demography expansion of Barcelona. On the other hand, another sector could be differentiated in the North part of the region, represented basically by the municipalities of Martorell, Olesa de Montserrat and Esparraguera where the influence of the metropolitan area of Barcelona has happened later and in a smoother way.

The population and economy of the Baix Llobregat are not distributed in a simple way; there are some internal and external factors that influence this distribution causing heterogeneity in the region. The most important territorial factors that cause a considerable effect in the industry are the orography, the demographic distribution, the situation and the communications.

Talking about the internal factor mentioned before, is important the variability in the orography of the region, since the Baix Llobregat is in a river basin we could found different landscapes, from mountain in the North and the West side to the floodplain in

the centre and the delta downstream of the Llobregat river which are places with a smoother slopes.

We could see some socioeconomic differences around the region due to the coexistence of different types of municipalities as a result of the transformations of the population that have been happen till the present. Urban population centers next to rural population centers; self-employed companies that try to subside next to important enterprises or urban residential zones next to municipalities with a high industry presence are examples of the heterogeneity of the region.

The demographic distribution of the region is extremely influenced by the economic development of Barcelona and its metropolitan area. This fact causes that a high percentage of the population is placed in the South and East sides of the region, which are near and have better communications in terms of transport with the capital.

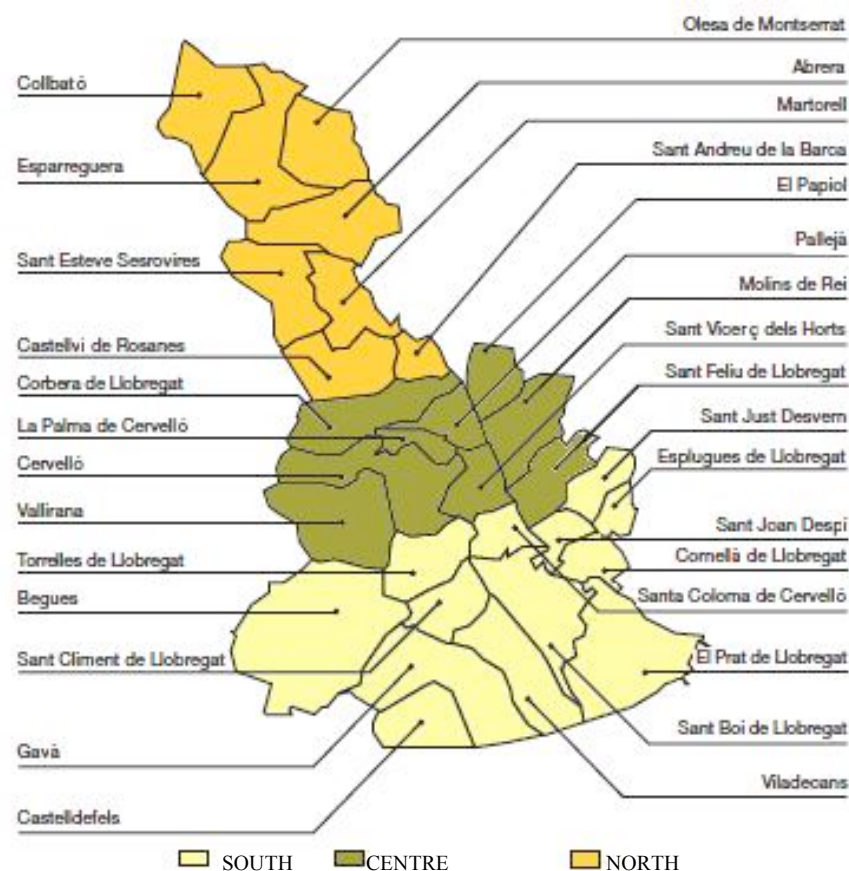


Figure 3.5.Subdivision of the region of Baix Llobregat.

Castellbisbal, Rubí and Sant Cugat

Each of these municipalities belongs to the region of Vallès Occidental and are placed in the South. We could clearly differ two types of municipalities, Rubí and Sant Cugat which are basically places that the population have chosen to live along the lasts years due to its strategical position, near from Barcelona and other industrial cities such as Terrassa or Sabadell, but which have not an important effect in the sector of industry in the region. On the other hand, Castellbisbal, which in terms of population is not as big as the others but it, contains an important part of the industry increasing its contribution to the economic development of the region. It is due to the fact that Castellbisbal is

placed next to Llobregat River, which has been used till the present as a factor for the industrial development.



Figure 3.6. Municipalities of Vallès Occidental in the influence zone.

Castellbisbal is one of the biggest municipalities of the region, is placed in a rough terrain in terms of geography. A few years ago the agriculture was the principal economic activity, but due to its strategic position, placed near from different communication poles, the industry has grown in the last years. In such a way, some industrial polygons have been built (Actually 8 polygons but there are other under construction) transforming this area in one of the most productive municipalities of the province of Barcelona.

In the early 60's starts the industrialization of Castellbisbal, an important factor for this development was the high percentage of immigration coming from the rest of Spain, thing that confirms the beginning of the end of the agriculture activity.

This industrial growth has been continuously increasing till nowadays, introducing also immigration from other countries, which increase considerably since the XXI century.

Talking about the communication and transport, there are some infrastructures that pass through the municipality helping to improve the entrance/departure of the cargo to/from

del Vallès, at the West side with Ullastrell, at the East side with Sant Cugat and in the South with Castellbisbal.

Rubí is one of the most inhabited cities of Catalonia and particularly of the region of Vallès Occidental. The principal employment of the municipality is focus in the service sector (47.9%), basically in the industry (40.1%) of the nearby industrial polygons.

As it happens in Castellbisbal, the agriculture and livestock activities which had been the principal sector of the economy in Rubí till the XX century, reaching the 92,6% of the region surface some years ago, have become residual activities in the present.

To finish with the delimitation of the territory, Sant Cugat is placed in the North side of the Collserola mountain chain, near from Barcelona and communicated with the capital through the Vallvidrera's tunnels. It has an extension of 48.32 km² and borders with Rubí, Barcelona and Cerdanyola at the East, South and West respectively.

In the last Century the arrival of the Catalan railway to Sant Cugat had caused a significant change in the city, which transforms the city from a rural aspect to urban city, suffering one of the most important urbanizations in the region.

Although some important companies like TVE or HP have chosen this municipality to place their office, the industry development is much less remarkable than in the other cities analysed before.

Gijón

Gijón is the largest city and municipality in the autonomous community of Asturias in Spain. It is located on the Bay of Biscay, approximately 20 km North of Oviedo, the capital of Asturias and 26 km East of Avilés.



Figure 3.9. Location of the municipal term of Gijón in Asturias.

The city is divided in six districts: Centre, East, South, West, El Llano and Rural. In this last one, the entire peri-urban zone and the rural parishes are integrated. This area has a good connection to the motorways and highways national network that make it be well connected with other cities both Asturias and the rest of Spain.

During the 20th century the town was heavily dependent on mature heavy industries. The carbon industry had traditionally a big importance in the economic development of the city. During the sixties, the creation of the Uninsa factory (Ensidesa) and the harbour activity cause an important economic growth in the city and a change in its industry sector.

After the seventies the tertiary sector employment began to expand rapidly along with the city's population, which by 2007 stood officially at 277,897 for Gijón, and approximately 380,000 for the total Gijón agglomeration.

The port is at the centre of many of the local businesses. Apart from directly port related activities, the economy is based on tourism, steel, other metallurgy, livestock rearing and fisheries.

3.1.2. Population

The number of inhabitants in a region is one of the most important factors that determine its economic growth and the future development. According to the data obtained from IDESCAT, the population of the region of Baix Llobregat corresponding to the last year was 803,651 inhabitants, distributed in 30 municipalities. Most of this population lives in the South of the region where we could find the most important cities such as Cornellà de Llobregat, Esplugues de Llobregat or El Prat de Llobregat, this fact is due to the proximity of these regions from Barcelona and the facilities in term of communication and public transport that its municipalities have.

We could see in the table below the variation of the population at different scales in the regions of interest for this socio-economic analysis. Particularly it is possible to observe the inhabitant growth in the region of Baix Llobregat and in the influence zone of the LIFE GAIN project. Both of them are practically equal, fact that remarks the importance of the population growth in the municipalities which will be directly affected with the activity of this project.

More specifically, the population of the influence zone has grown 193.511 inhabitants in the last 30 years, which represents a growth of 101,12%, so this area has doubled its population. During these years the five-year growth has considerably increased from 1985 to 2005 because of the important industrial development of the region, reaching almost the 25% in the last five years of this period. From 2005 to the present the population has continued growing, but it happen in a smoother way, partially due to the economic crisis of the country and other socio-economic factors of the region.

On the other hand, we can see that in Gijón the population has not suffered such important development like in the other areas. Its population has increase or decrease during the years according to the economic and industrial development of the city and presents different trends along the last years. This evolution is related to the importance of the area in the country industry and the significant changes that the city suffers along the history.

The population of Baix Llobregat, the influence zone and Gijón:

	Catalonia	Province of Barcelona	Baix Llobregat	Influence zone	Castellbisbal	Rubi	St.cugat	North Baix Llobregat	Centre of Baix Llobregat	Gijón
1985	5,978,638	4,614,364	583,354	191,376	4,087	46,360	35,302	48,801	56,826	283,878
1990	6,059,494	4,690,996	610,192	210,281	4,725	50,987	39,316	52,198	63,055	285,174
1995	6,090,040	4,628,277	643,419	235,471	5,864	53,100	44,956	58,708	72,843	296,765
2000	6,343,110	4,736,277	692,892	273,310	7,887	58,646	52,654	70,962	83,161	290,934
2005	6,813,319	5,226,354	741,024	338,988	10,842	69,102	70,514	87,106	101,424	299,007
2010	7,493,252	5,511,147	798,468	374,436	12,223	73,591	81,745	95,415	111,462	302,822
2015	7,508,106	5,523,922	806,651	384,887	12,364	74,536	87,830	97,004	113,153	299,684
Variation										
2015/1985	1,529,468	909,558	223,297	193,511	8,277	28,176	52,528	48,203	56,327	15,806
%	25.58	19.71	38.28	101.12	202.52	60.78	148.80	98.77	99.12	5.50
% 85-90	1.35	1.66	4.60	9.88	15.61	9.98	11.37	6.96	10.96	0.40
% 90-95	0.50	-1.34	5.45	11.98	24.11	4.14	14.35	12.47	15.52	4.00
% 95-00	4.16	2.33	7.69	16.07	34.50	10.44	17.12	20.87	14.16	-2.00
% 00-05	7.41	10.35	6.95	24.03	37.47	17.83	33.92	22.75	21.96	2.77
% 05-10	9.98	5.45	7.75	10.46	12.74	6.50	15.93	9.54	9.90	1.27
% 10-15	0.20	0.23	1.02	2.79	1.15	1.28	7.44	1.67	1.52	-1.10

Table 3.1. Population of the area studied. Source: Own elaboration with data from IDESCAT [5] and [6].

	% North and centre / South	% B.Llob/ Cat	% Inf. Z / Cat
1985	27.6	9.7	5.3
1990	28.1	10.0	5.6
1995	29.1	10.5	6.2
2000	30.6	10.9	6.9
2005	34.2	10.8	7.7
2010	34.3	10.6	8.0
2015	34.6	10.7	8.2

Table 3.2. Ratio between populations. Source: Own elaboration with data from IDESCAT [5].

Another remarkable aspect derivable from the data of the tables is that in the last years the population of the influence zone that have been studied in this project increase its percentage with respect the whole Catalonia. In 1985 it represented just a 5.3% of the total population with respect the 8.2% that represent nowadays, it means that the annual growth of this region (3.3%) have been faster than the total annual growth of Catalonia which is around the 1%. The Baix Llobregat and the Vallès Occidental regions are the regions of Catalonia whose number of inhabitants have been more increased in the last 30 years.

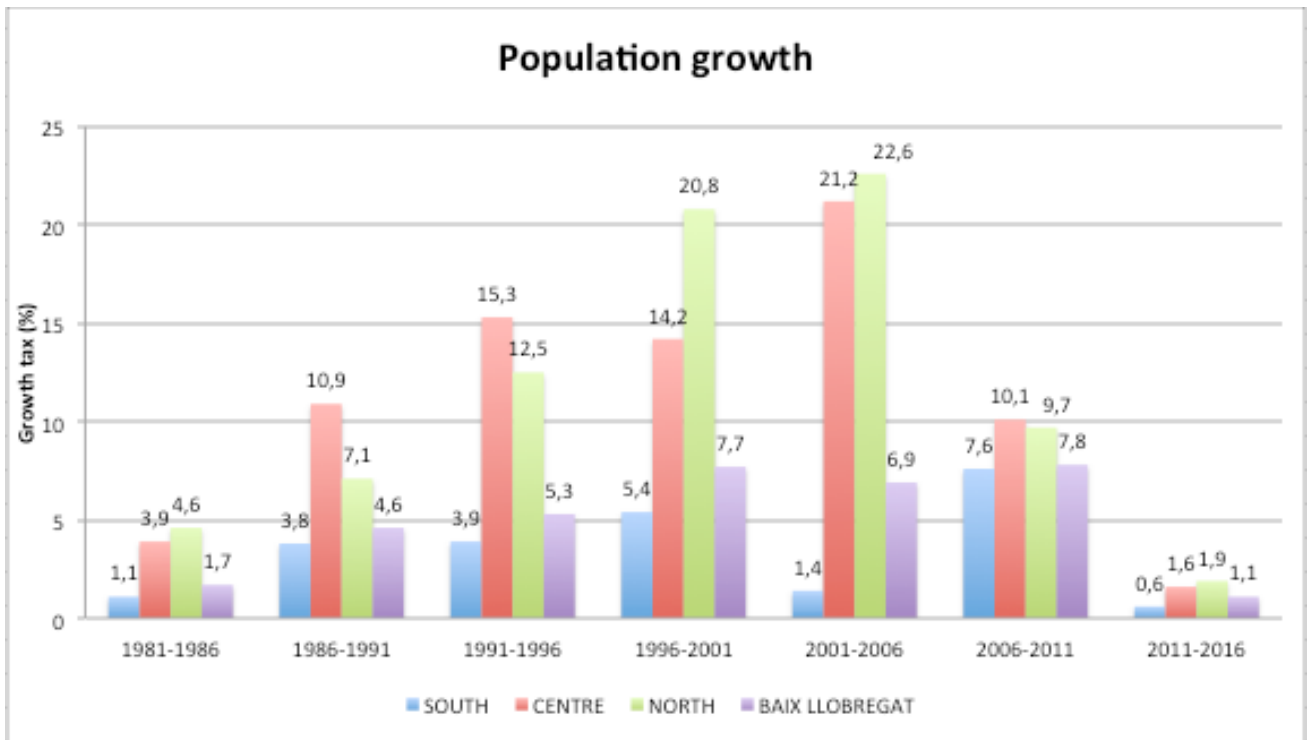


Figure 3.10. Population growth (1981-2016). Source: Own elaboration with data from IDESCAT and [7].

Every day, the population of the metropolitan area of Barcelona such as the centre and North part of Baix Llobregat and some municipalities of Vallès occidental is taking more importance in the demographic aspect to the detriment of the nearest regions from Barcelona such as the South part of Baix Llobregat. Despite the fact that it has the 76% of the population of the region, this percentage is reduced year by year, this is partially due to a territorial reorganization process of the Catalonia's population.

The relative growth of the population, we have seen in the figure above, allow us to identify different residential patterns in the region during the last years. The North part of the region is where the most important growth has happened, reaching values of 23% in the period 2001-2006. This fact is directly related to two important factors: on the one hand due to the improvement of the communication infrastructures of the territory, thing that makes the access to this zone easy. On the other hand, the price of the land is the other determinant factor for this growth since it is cheaper in comparison with the municipalities placed next to Barcelona.

In the centre of the region, although it has experimented a lower growth in its population with respect the North part, it is the only one that has kept the same trend during the last 30 years.

Talking now about the South part we can observe that is here where the smoother change in the population has happened, although in the last for years the growth rhythm has been incremented considerably.

In the figure below the territorial distribution of the population growth at the municipalities level in the period 1996-2016 is exposed. The municipality that suffers the biggest change in terms of inhabitants is Castelldefels, reaching more than 60,000 inhabitants in the present. If we take into account the entire region and the

municipalities of the influence zone, the most important growth is placed in the North part of Baix Llobregat. On the other hand some municipalities like Esplugues or El prat, placed in the South part are the only ones which have lost population with respect to a few years ago.

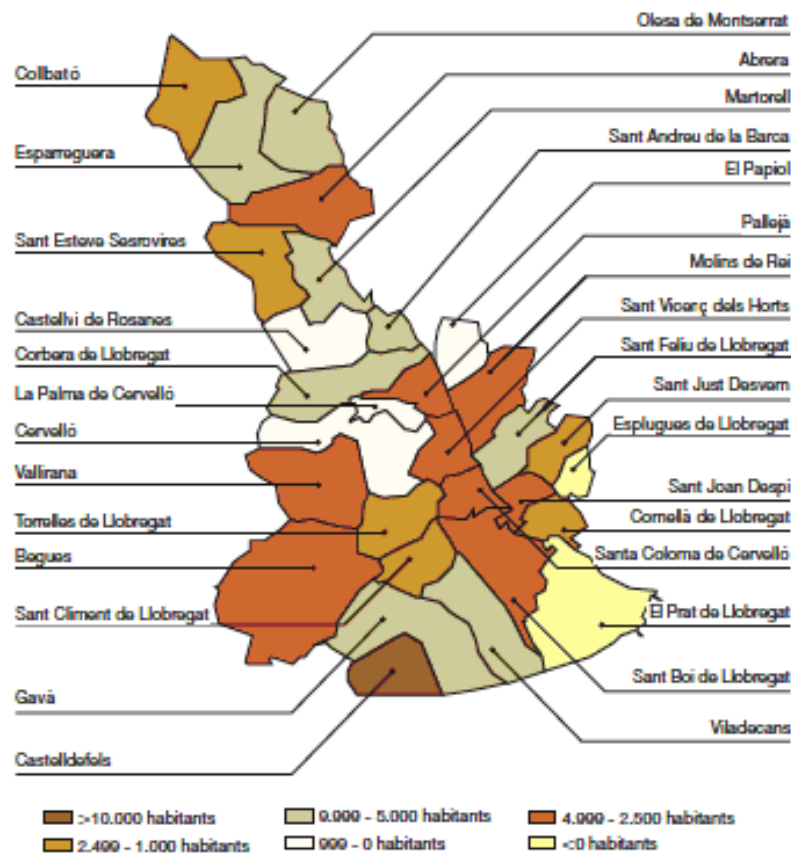


Figure 3.11. Variation of the municipalities inhabitants (1996-2016).Source: Own elaboration with data from IDESCAT and [8].

To sum up, all these facts described above show us that any industrial development or activity in this area such as which will take place in the GAIN project, will affect to a big amount of people and every year this number will increase, so it is important to take into account all the possible social, economic and environmental impacts that it could produce so a lot of indicators of the life quality of these inhabitants could be seriously affected if we do not take the necessary measures to reduce its impact.

3.1.3. Demographic characteristics

The structure of the population in terms of age and sex of the influence zone is just a little bit different in comparison with the rest of Catalonia. The age pyramid of this area show us that the population of the region is much younger than the average of Catalonia since the 18.56% of the inhabitants are younger than 15 while in Catalonia this percentage just reach 15.85%.

On the other hand, a 40.64% of the population in the influence zone are between 16 and 44 years old (39.36% in Catalonia), a 26.32% are between 45 and 64 years old (26.38 in Catalonia) and finally a 14,48% are older than 65 (18,31 in Catalonia). All this data

shows us that the region affected by the activities of the LIFE GAIN project have a high percentage of population, almost 67%, who is between 16 and 65 years old, which is the age that is suppose active in terms of searching job and work. Therefore, in the next years this amount could be increased since the area has more young people than pensioners.

In the case of Gijón just the 11% of the population is under 15, the 34,4% is between 16 and 44 years old while the 30.84% is between 45 and 64 and finally the 23.92% is older than 65. With this data we could see that the population of this area is older in comparison with the Catalan one. Although the impact of the project in the working population of the region will be lower in Gijón than in the influence zone of Catalonia since there are more actions planned in the surrounding area of Baix Llobregat, it is important to take into account that the population in the North will be every year older and the renovation of this will not be produced in the same way than in Catalonia regions.

According to the data presented in both age pyramids we can deduce that the operations of the project that will generate new jobs will be a positive aspect in the area affected especially in the Catalan influence zone, so there is a lot of people who will be candidate to access to this jobs allowing them to improve their economic income and the life quality.

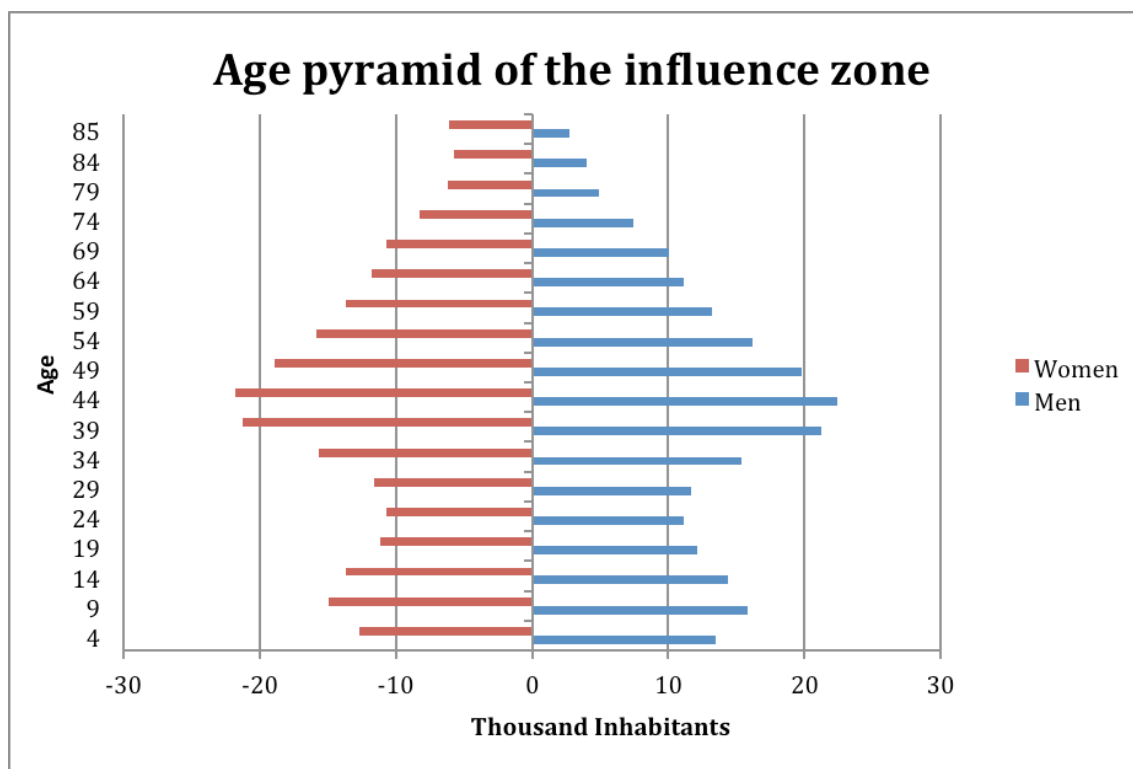


Figure 3.12. Age pyramid of the influence zone. Source: own elaboration with data from IDESCAT [5].

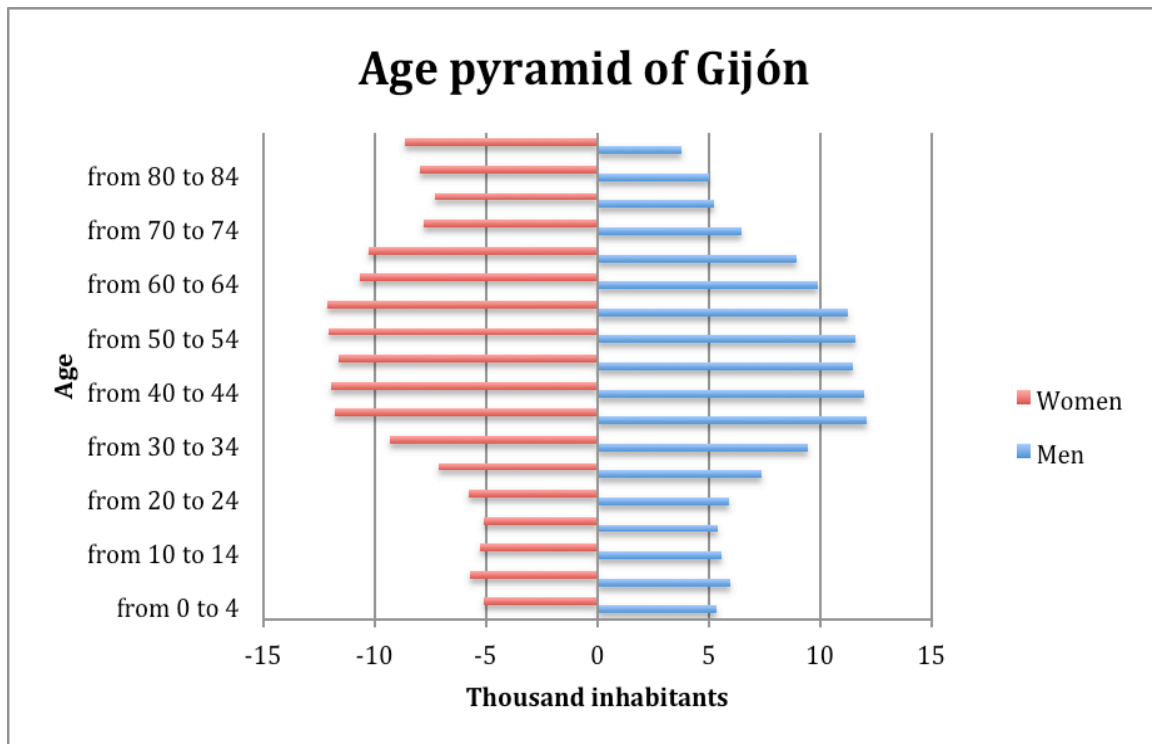


Figure 3.13. Age pyramid of Gijón. Source: Own elaboration with data from [9]

Talking now about the distribution of the population in terms of sex, in the influence zone of the project the percentage of the men and women is practically equal, 49.6% and 50.4% respectively, this trend is according to the rest of Catalonia where the women population is just slightly bigger than the fifty per cent. Otherwise in Gijón the difference between sexes is slightly bigger since there is a 52.13% of women and a 48.87% of men

Another remarkable aspect derived from the both figures above is a significant predominance of the female sex in the age group of inhabitants with are older than 65, showing once more what different studies around the world verifies, that women life expectancy is higher than men.

In the last years the population of the Baix Llobregat and Vallès Occidental have suffer an aging process, but in a smoother way in comparison with the rest of Catalonia. The aging index, which establishes a relation between the population older than 64 years and younger than 15 years, is 78%, significantly lower than the 115% that is the value of Catalonia. This fact means that approximately every 8 persons older than 64 there are 10 younger than 15. Other demographics indicators are presented in the table below:

	Influence zone	Catalonia
Aging index	78	115
Childhood index	19	16
Youth dependency index	28	24
Senile dependency index	22	28
Replacement index of the population in working age	98	117
Rate of child to women in fertile age	24	22

Table 3.3. Population index for its characterisation. Source: own elaboration with data from IDESCAT [5].

- Inhabitants older than 65 per 100 inhabitant younger than 15 years
- Inhabitants between 0 and 14 per 100 inhabitants
- Inhabitants younger than 15 per 100 inhabitants between 15 and 64 years
- Inhabitants older than 65 per 100 inhabitant between 15 and 64 years
- Inhabitants between 60 and 64 per 100 inhabitants between 15 and 19 years
- Inhabitants between 0 and 4 years per 100 women between 15 and 49 years

Most of them have similar values in the influence zone and in Catalonia, with the exception of the replacement index of the population in working age, the senile dependency index and the other index previously mentioned. These three indicators confirms that the population of this area is younger than in the rest of Catalonia and that the percentage of people ready to carry out the relief in the labour market is higher in the influence zone than in Catalonia.

With this structure of the population we could be sure that the new employment generated will satisfy the needs of the population and that there are enough young people in the area to keep the economic development during the next years.

3.1.4. Distribution of the population

As we can observe in the Figure 3.14, the most important focus of population is in the South part of the region, especially in the municipalities placed next to Barcelona such as Esplugues, Cornellà or Sant Cugat where the number of inhabitants is considerably higher than 60,000.

Another focus of inhabitants could be seen in the North region of Baix Llobregat, more specifically in the municipalities of Martorell or Sant Andreu de la Barca, where the industry has an important weight in its economic development. In the municipalities that form the centre of the region, the orography is steeper so the population is lower since the access to the infrastructure net is much more difficult.

Most of the municipalities in the North of the region are residential areas and the population is being increased in the last few years. A high percentage of this population have to move themselves to another municipality to access to the job like Martorell or Castellbisbal, since the industry is normally placed next to the Llobregat river where the territory is not such steeper and the resources supplied for the river and the main transport infrastructures are better.

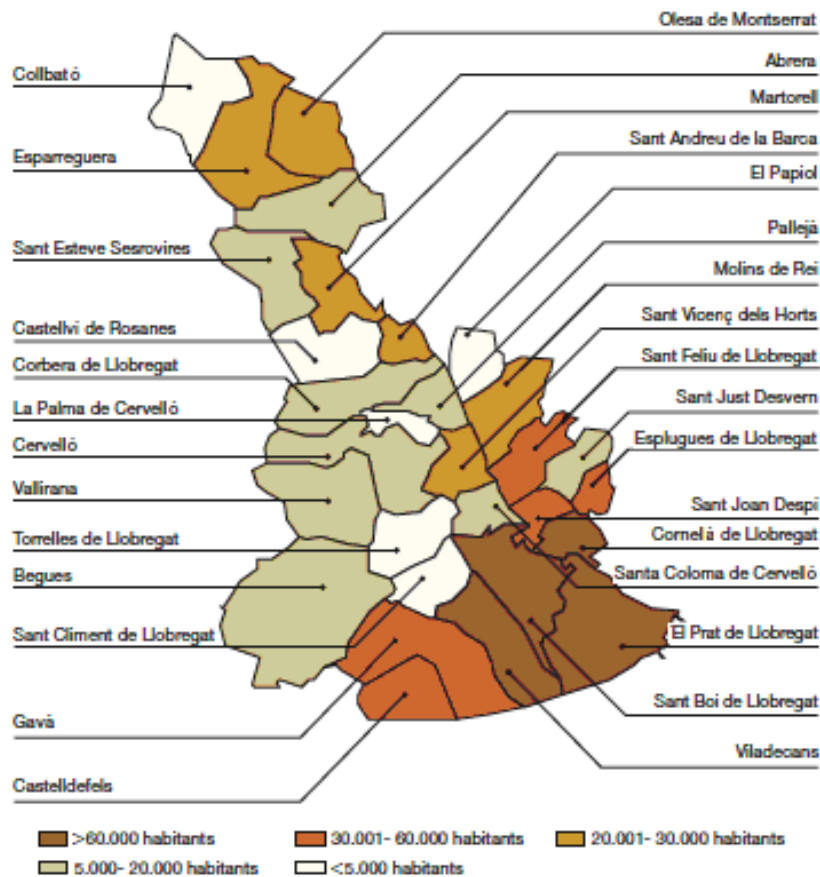


Figure 3.14. Distribution of the population (2008). Source: Own elaboration with data from IDESCAT and [7].

In terms of demographic density the South part of the region is where we found the highest densities, Cornellà de Llobregat or Esplugues de Llobregat have the maximum values (12,336 hab/km² and 9,918 hab/km² respectively). On the other hand are also remarkable the densities of Sant Joan Despí, Sant Andreu de la Barca and Castelldefels which are almost 5,000 hab/km².

It could be seen in the figure below that actually exist a big difference between the demographic density of the municipalities of the North and centre part of the region and these ones placed in the South. This differences are produced because almost the 65% of the population live in the South and it increase the ratio inhabitants per kilometre, but nowadays this distance between the diferent densities has been reduced considerably respect few years ago, and some studies predict that this trend will continue during the next years since the population in the North and Center of the region is being increased year by year because of the better quality of life that this area offers to the population.

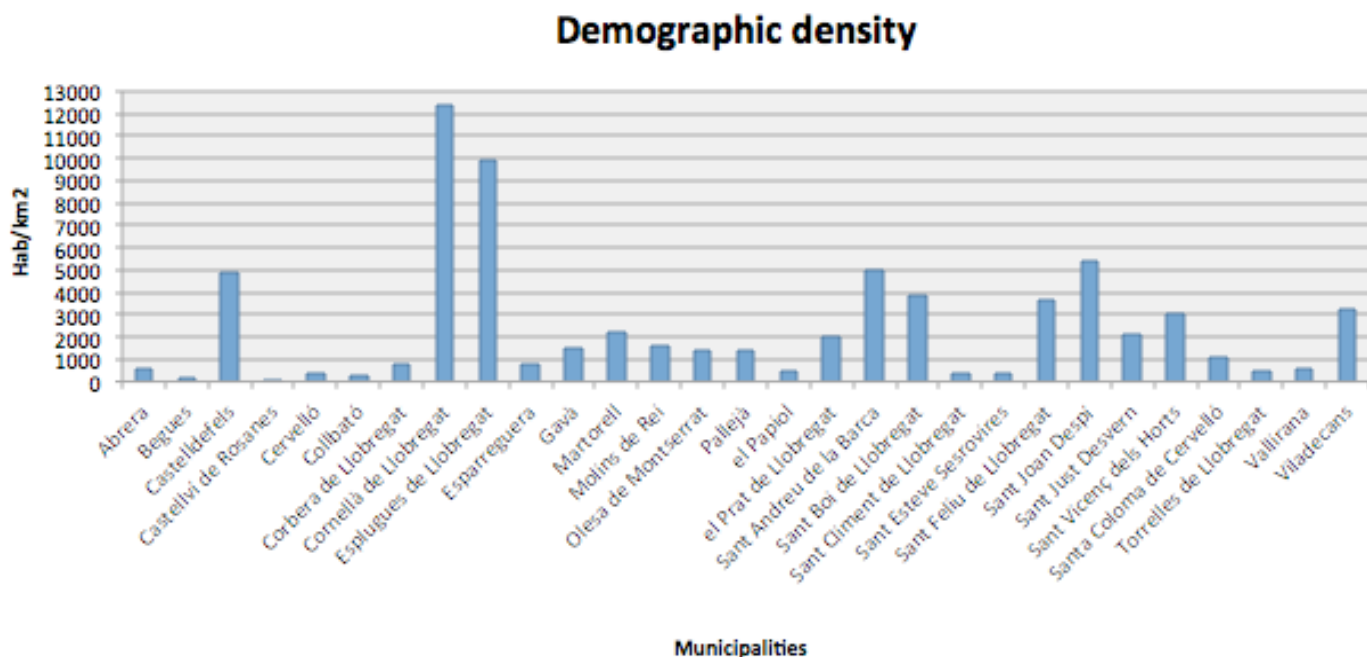


Figure 3.15. Demographic density of the municipalities of Baix Llobregat. Source: own elaboration with data from IDESCAT[5].

What about the Vallès Occidental, it is a region with a high population density (1,398 hab/km²) especially in the municipalities on the middle and the South part such as Rubí, Sant Cugat. Both of them are urban centers with an important population and industry density where we can find several industrial polygons placed next to the most important communication infrastructures. The demographic increment in these municipalities happened because of the natural growth of the population, people who leave Barcelona searching an improvement in their life quality and the new migratory fluxes from other parts of Catalonia and Spain.

The North part of this region which is not included in the influence zone of this project, is steeper than the rest of the territory and it is plenty of urbanizations with very low population density, it has more rural or residential aspect.

We could see in the figure below an important difference between the demographic densities of the three municipalities of interest in our project. This fact is due to a different distribution in the use of the land, since in Castellbisbal there is a high percentage of it dedicated to industry, while in Rubí and Sant Cugat, although both of them have several industrial zones, it is more common to find bigger urban areas with a residential purpose.

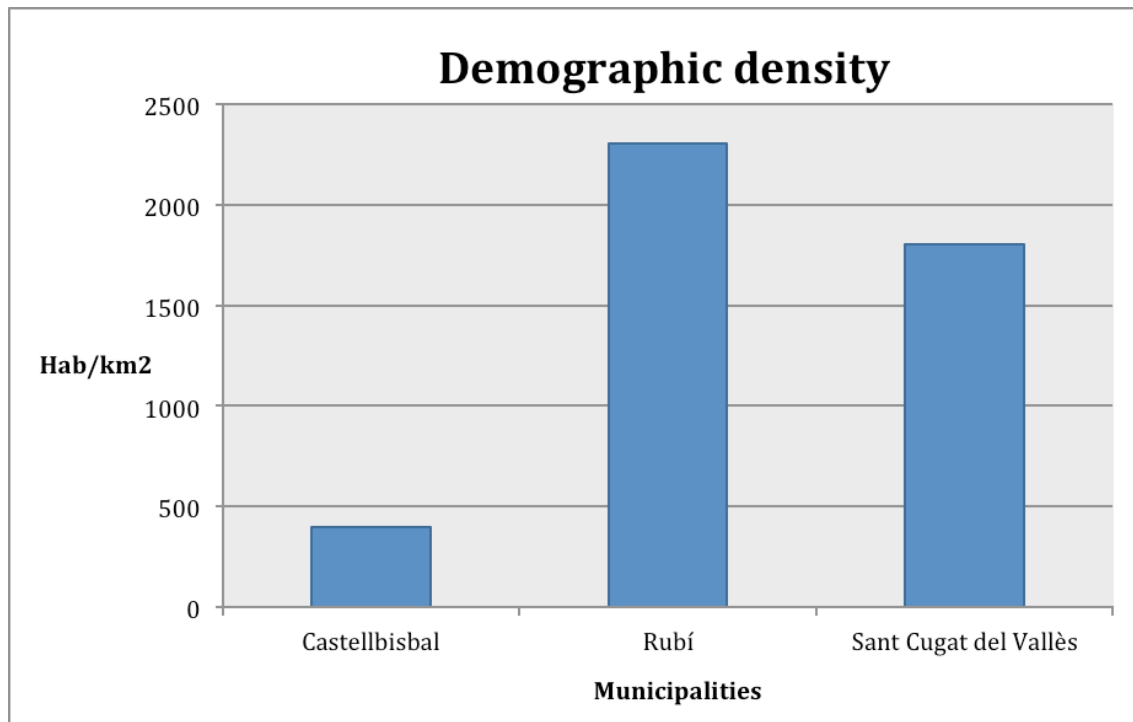


Figure 3.16. Demographic density of the municipalities of Vallès Occidental. Source: own elaboration with data from IDESCAT[5].

These differences in the distribution of the population in the territory will influence in a significant way in the mobility of the population since a big amount of trips are generated every day due to the people who have to leave their municipality to go to their job placed in a nearby city. It is exactly the case of Rubí and Sant Cugat, where many people goes to other municipalities to work. This situation will suppose that any new industrial activity or job generation will affect directly the people from the nearby municipalities.

Most of the activities planned in this project such as the field tests (which are developed in Castellbisbal and Gijón) and the valorisation of the plan in Vallirana will generate new jobs and with it a demand of mobility in this locations. This fact will affect to some indicators of the quality of life improving it values and generating richness in the surrounding area.

3.1.5. Projection of the population in the short term

Now we are going to talk about the evolution of the population in a short term. According to the research done by “Institut d’Estadística Català” (IDESCAT) we can establish three different scenarios, the high scenario corresponding to a fast economic recovery, the medium one corresponding to a smoother recovery of the situation in economic terms and the low scenario which presents an extension of the economic crisis.

According to the projections of the population in Catalonia, it will slightly diminish in the next year to increase until 8 millions of inhabitants in 2051. Partially due to the economic crisis the births are going to be reduced, reaching the levels of the 90’s and

the life expectancy will continue increasing as a result of the development an investigation of new medical methods.

The medium scenario is the most plausible if we analyse the demographic dynamics in the last years. In this way, the number of 7,479 million inhabitant registered in 2013 will be reduced progressively till 7,333 million in 2018 and will be recuperated along the forward years, reaching 7,456 million in 2026, this positive trend is going to continue until 2051 when the population will be near from 8 million.

This first negative trend is the effect of the combination of two factors, a negative natural growth, with higher number of deaths than births and a negative migration balance with more emigration than immigration which will not be reverted until 2017.

If we pay attention to the other scenarios we will realize that both predict considerably different trends with a difference of 3.5 million people in 2051. The highest scenario concludes that the population will not suffer any decrease and it will reach 9,676 inhabitants. On the other hand the low scenario is not as optimistic as the last one, concluding that the initial negative situation presented in de medium scenario will be keep in the future where the Catalan population will remain near from 6 million people.

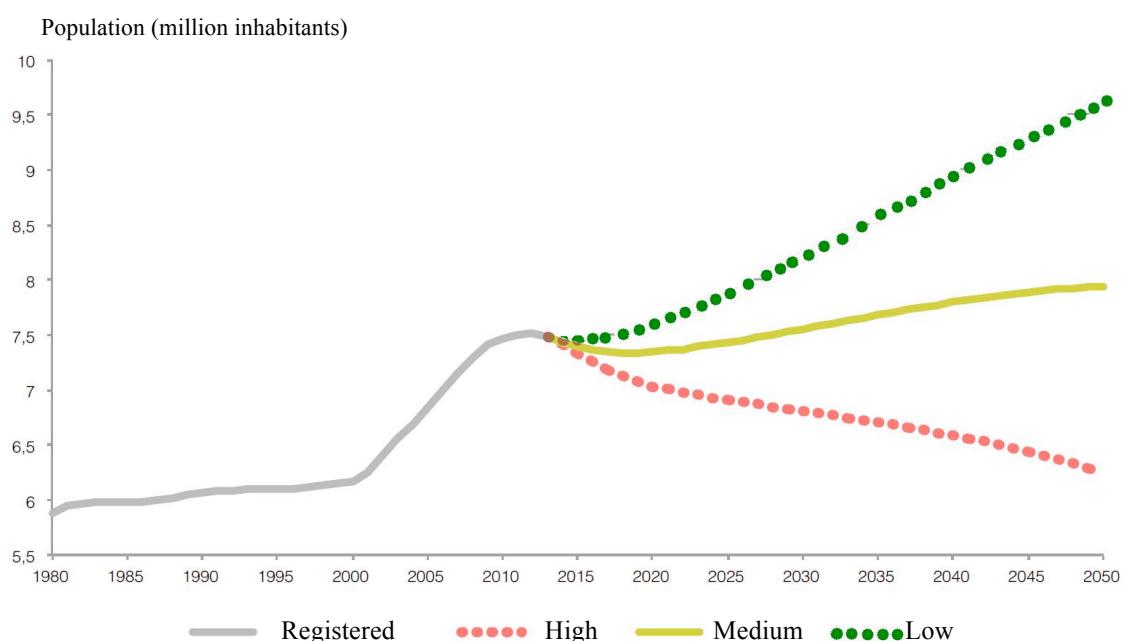


Figure 3.17. Projection of the population in different scenarios. Source: [10].

Another important aspect in the evolution of the population in the next years is that the 75% of the regions will diminish the number of inhabitants. According to the medium scenario 39 Catalan regions, included Baix Llobregat and Vallès Occidental will suffer a decrease in its population and just one of each four regions will recover the previous number of inhabitant in the horizon 2026.

The most affected regions will be these placed in the North and the South West of Catalonia since they are far from an important metropolitan area of the capital province such as Barcelona, Tarragona, Girona or Lleida. Likewise, during the period 2013-2025 the regions of Barcelonès, Vallès Oriental, Baix and Alt Penedès, Garraf and Segrià will

present the biggest growth in terms of population. If we divide Catalonia in territorial areas it is possible to say that the zone that will suffer the major development is the Mediterranean coast.

The region of Barcelonès and the metropolitan area will decrease its population in a short term (2018) but it is going to be recovered in a medium term (2026) although it will has a different distribution due to the present processes of demographic reorganization that the area is suffering where there is a positive flux of population from the city of Barcelona to the regions placed in the metropolitan areas.

Distribution of the population in Catalonia.
Medium scenario 1986-2026

	Percentatges			
	1986	2000	2013	2026
Metropolità	68,4%	66,3%	63,5%	63,6%
Barcelona ciutat	28,4%	23,7%	21,4%	21,6%
resta Barcelonès	11,3%	9,6%	8,3%	8,3%
resta Metropolità	28,6%	33,0%	33,8%	33,7%
Comarques Gironines	8,0%	8,7%	9,8%	9,7%
Camp de Tarragona	5,6%	6,2%	6,9%	6,9%
Terres de l'Ebre	2,6%	2,5%	2,5%	2,4%
Ponent	4,9%	4,8%	4,8%	4,9%
Comarques Centrals	5,3%	5,4%	5,3%	5,2%
Alt Pirineu i Aran	1,0%	1,0%	1,0%	0,9%
Penedès	4,2%	5,2%	6,2%	6,4%
Catalunya	100,0%	100,0%	100,0%	100,0%

Population growth according to the medium
scenario 2013-2025(%)

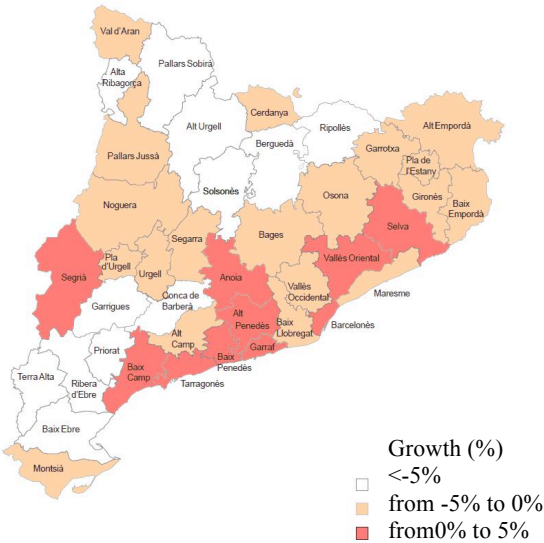


Figure 3.18. Percentage of population distribution and population growth (2013-2025). Source: [10]

It is foreseen that the Catalan active population reduce its volume till 4.4 million in 2051 and the evolution of the demographic structure and the migration will not help to this fact.

Nowadays, Catalonia presents a clear trend of population aging due to the higher number of deaths than births. It is predicted that actual active population (4,918 million) will be diminished 200,000 inhabitants at 2026 and although the positive migration balance, which will start this year, this number is going to decrease until 4,386 million in 2051.

If we analyse more in detail this population we can conclude that the percentage of young people will be reduced in comparison with the old people, fact that started 10 years ago but which effect can be considerably notable in the next years. The total amount of workers older than 45 will represent the 47.1% in 2031 and the 43,2% in 2051. This subdivision of the population has recently suffered a significant increment in the last decades because of the migration and people born during the 70's and 80's, reaching levels of 5 million people in 2010 but the factors mentioned before and the economic crisis are important issues that do not help to keep this trend.

Evolution of the active population

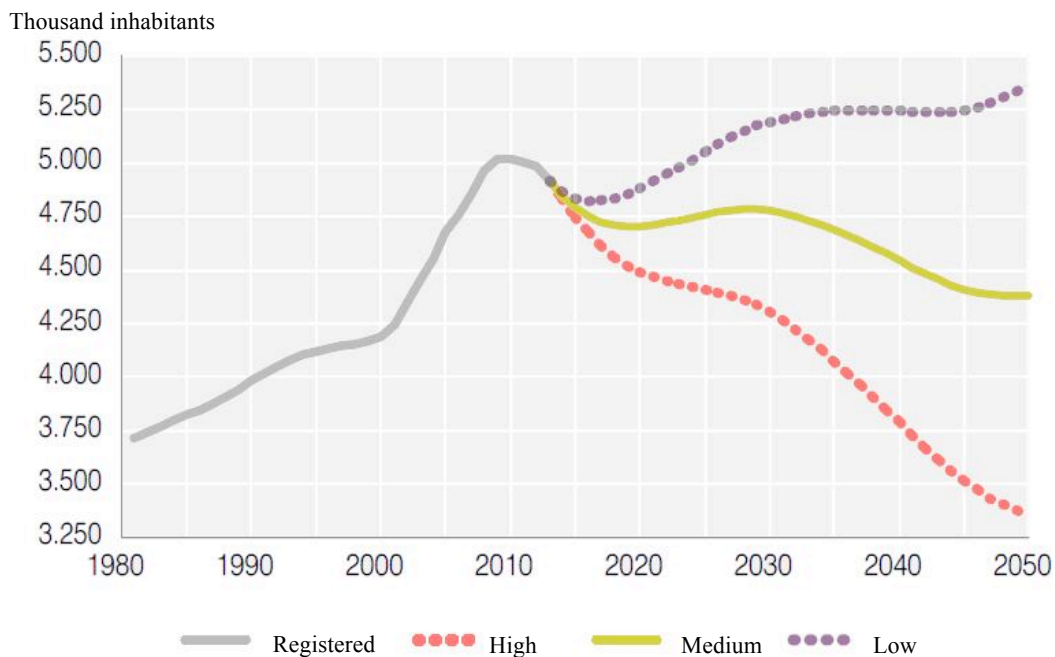


Figure 3.19. Evolution of the working population in the next years. Source: [10]

Some of the different factors and trends presented above could be clearly seen analysing the age pyramid and its evolution. In many European countries this pyramid has changed its form along the last decades according to the demographic variations in the continent. In the Catalan one it is possible to observe how the aging of the population will happen by comparing the pyramids of different years, concluding that in the present the birth rate is lower than in the 80's and it produces a change in the aspect of the age pyramid and its evolution in the next years.

In the 2051 horizon it is foreseen that the population older than 65 will represent a high percentage of the total population, producing some important problems to manage the retirement pensions and to allow the active population to satisfy all work demand.

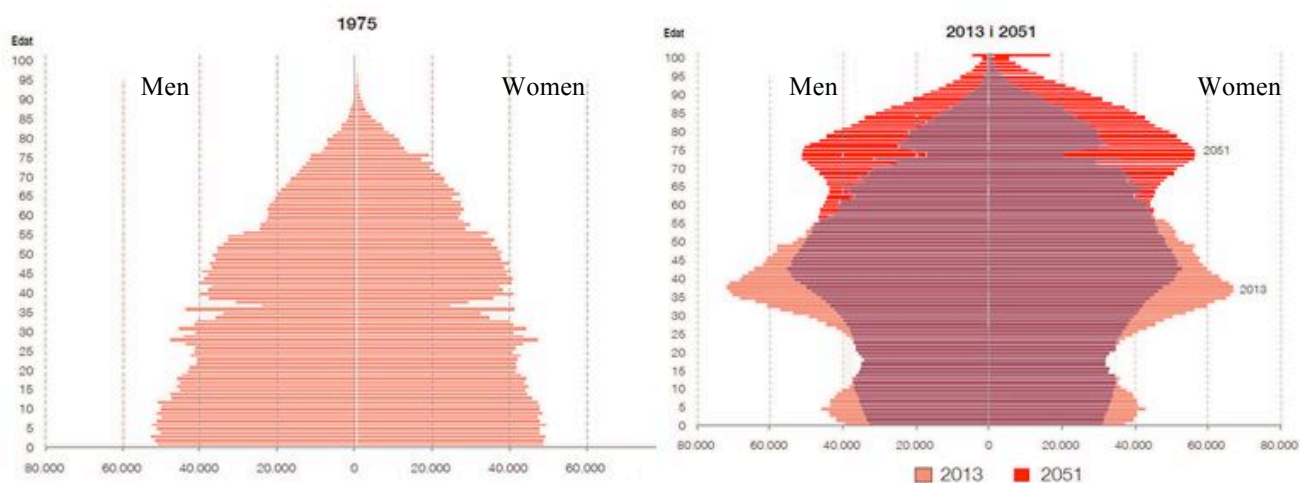


Figure 3.20. Age pyramid of the influence zone in 1975 and comparison between 2013 and 2051. Source: [10]

On the other hand, in the case of Gijón, according to the research done by “Sociedad Asturiana de Estudios Económicos e Industriales”, (SADEI) it is possible to have an idea about the estimation of the population evolution during the next years. It is based under a scenario that supposes a positive economic trend during the next years keeping the smoother recovery happened in the last years.

The projection foresees that the population of the city will slightly decrease in the next years, reaching levels of 289,963 inhabitants in 2020 and until 274,989 in 2029. This fact could be due to different factors but one of the most important is that the autonomous community of Asturias is losing impact in some of the industrial sectors and its contribution in the economic development of the country and in the Gross Domestic Product (GDP) is every year lower. This situation will turn into a decrease in the population in the whole region during the next years not only in the city of Gijón.

The migration of the population and the aging process of the inhabitant of the region have also influence in these predictions. It is important to remark the higher number of deaths than births in the territory, which will diminish the population until 971,009 in 2029, causing a decrease of 87,967 inhabitants. This situation for the future is similar than the previously exposed for the Catalan territory.

Analysing more in detail the structure of the population we can conclude that the percentage of young people will be reduced in comparison with the old people, fact that it is notable in the present but that will be incremented during the incoming years. The total amount of inhabitants older than 64 will represent the 31.63%, which means an increment of 7.7% and more than the 60% of the population will be older than 45 (63.96%). This is a trend difficult to solve in a short term and that will suppose an inconvenient for the active population in the future.

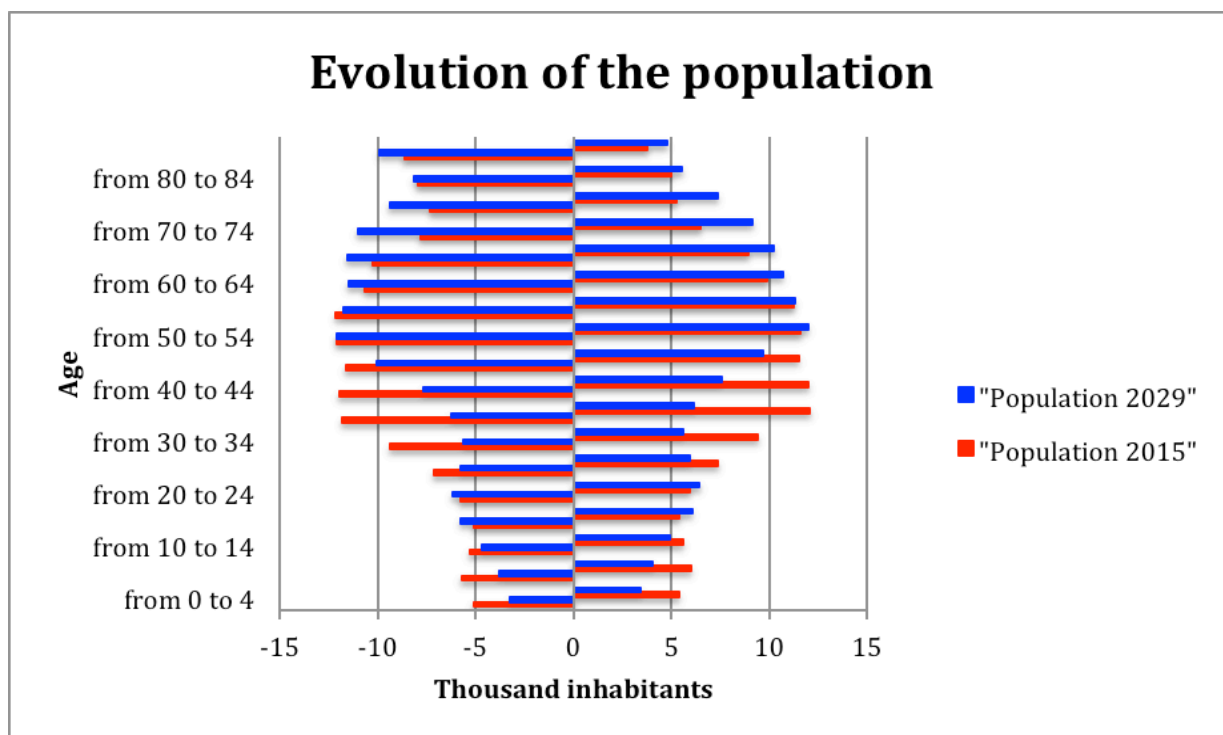


Figure 3.21. Comparison of the age pyramid of Gijón in 2015 and 2029. Own elaboration with data from SADEI [11].

3.2. Local productivity

3.2.1. Business network

Taking into account the growth of the Catalan economy, there is a clear difference in terms of the GDP among the regions. The ones that are near from Barcelona have a higher weight in the Catalan production structure.

As we can see in Table 3.4, the regions of Baix Llobregat and the Vallès Occidental have the high percentage of the Catalan GDP, reaching a 22.5% in 2015 and suffering an important growth above the Catalan average in the last few years.

Weight in the Catalan GDP	%2015
Barcelonès	36.62
Vallès Occidental	11.81
Baix Llobregat	10.67
Vallès Oriental	5.26
Maresme	3.96

Table 3.4. Regional contribution in the Catalan GDP. Source: data from IDESCAT.

The productive activity of the influence zone (Baix Llobregat and some municipalities of Vallès Occidental) could be defined by four main features:

- The industry is still playing an essential role in the productive system, although the incoming increase of the tertiary sector in the economy of the region. The industrial fabric is so important and is the principal enhancer of the economy even though it suffers a small decrease because of the economic crisis, it still remains above the average of other Catalan regions.
- A service sector with a minor development respect the Catalan one, but in a constant expansion and with a weight in the region's economy above the 50%.
- A construction sector similar to the rest of Catalonia, but with an important difference since it has suffered an important development in the previous years of the economic crisis (2009) practically twice in comparison with the other sector of the region.
- A primary sector with a very low weight in the productive structure of the region and considerably below the average of this sector in Catalonia.

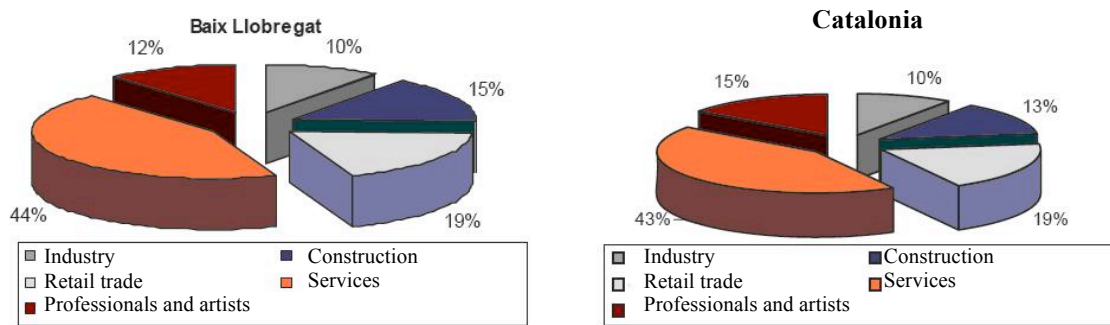


Figure 3.22. Distribution of the GDP in economic sectors.

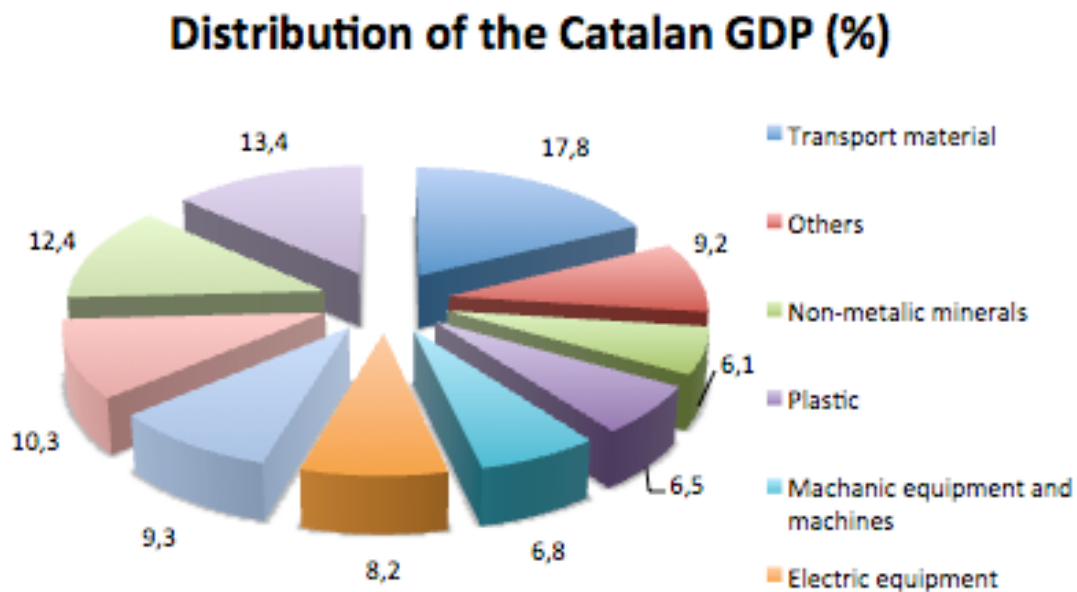


Figure 3.23. Distribution of the industrial GDP in Catalonia. Source: own elaboration with data from [7].

The working population and the structure of the GDP of the Baix Llobregat and Vallès Occidental show us the importance that actually have the industry and service sectors in the region studied.

The active population in the influence zone reaches the 55% of the total population in the area (221,687 inhabitants), but actually just the 42% have job (161,652 workers)[5]. Respect the year 2001, the active population has increased while the employed has decreased. The total amount of both classifications of people in the area is above the Catalan media.

Nowadays 50,035 inhabitants of the region are unemployed, this number had increase considerably from 2007 (15,920 inhabitants) till the present because of the economic crisis. The industrial sector is the one that has suffered the smoother variation in the amount of unemployed people while the construction sector has been the most affected by this phenomenon. Despite the increasing unemployment in the construction, the service sector is still having the major number of non-working people with more than the 50% of the total.

The industry sector is the one that has the highest percentage of working population. Almost a 23% of the GDP and the 19.76% of the people affiliated to the national social security belong to the industry sector, particularly; the siderurgy, metallurgy and machinery reach the 12.5% of the GDP. Moreover, the service sector has a 74.42% of the working population and generates the 70.7% of the regional production. The construction sector represents just the 6.4% of the local GDP and offers job to the 5.7% of the population while the primary sector only reach a 0.2% of the regional production.

	2004	2015	2004-2015
B. Llob- V.Occ			
Primary	0.70	0.20	-0.50
Industry	34.30	22.70	-11.60
Construction	8.70	6.40	-2.30
Services	56.30	70.70	14.40
Catalonia			
Primary	1.70	0.90	-0.80
Industry	27.00	19.50	-7.50
Construction	8.20	5.80	-2.40
Services	63.10	73.70	10.60
TOTAL	100.00	100.00	-

Table 3.5. Sectorial structure of the GDP. Source: [5] and [8].

In comparison with Catalonia, the industry in the influence zone of the LIFE GAIN project has a bigger importance in the productive structure. It has a higher percentage in the regional GDP while in the service and primary sector the activity of the region is lower than the Catalan one. As we can observe in the table the construction sector has a similar magnitude in both cases.

During the period 2004-2015, the industry of the area studied has suffered a loss of weight in the regional productive structure since its percentage in the GDP has been decreased from 34.3% to 22.7% although the area is still remaining one of the principal regions of Catalonia with bigger presence of industry and it has higher percentage in the GDP than the total average.

On the other hand we can conclude that the service sector have increased considerably their contribution in the production of the region so it becomes to represent a 14.4% more than in 2004. Talking now about the construction and the primary sector it's clear that both follow the same trend in Catalonia and in a regional level, decreasing their participation around 2% and 0.6% respectively.

Analysing more in detail the municipalities where the activity of the project could have more influence we could see that in most of them the industry has the major importance in the production in terms of GVA (Gross value added). We could distinguish two types of municipalities, first of all these ones where the industry sector is the principal activity and which will suppose a principal focus for the workers mobility, generating attraction to inhabitants from other municipalities who will go there to work. According to the table below, we can include in this category municipalities such as Castellbisbal, Martorell, Rubí, Abrera, Sant Andreu de la Barca or Sant Vicenç dels Horts.

A second category could be these municipalities where the service sector is dominant in the production activity and the presence of industry in the territory is not as usual as in the first category described. These municipalities usually have a residential aspect and it is common that its population leave the municipality because of their job. This kind of municipalities satisfies the demand of mobility generated by the first type described. Some of the municipalities that we can include in this category are Sant Cugat del Vallès, Esparraguera, La Palma de Cervelló or Corbera de Llobregat.

	Industry	Construction	Services
Sant Cugat del Vallès	13.40	3.88	82.72
Castellbisbal	53.52	2.30	44.00
Rubí	46.94	5.26	47.77
Martorell	57.40	1.22	41.36
Abrera	40.64	4.88	54.36
Sant Andreu de la Barca	34.50	5.36	60.00
Vallirana	26.00	10.27	63.57
Sant Vicenç dels Horts	38.63	6.40	54.72

Table 3.6. GDP distribution of the main industrial municipalities. Source [5].

We have seen that both regions studied in this analysis have a clearly contribution of the industry in the production activity, but it is also important to describe the distribution of it and the evolution during the last years since it will allow us to identify which area suffers the biggest development and where we could produce the highest effects when some economic activity is generated.

First of all, we will focus our attention in the region of Baix Llobregat where the major part of the industrial activity is placed in the South area that has 17,000 companies (70% of the region). Furthermore, the main municipalities in this sense are these ones which are place next to Barcelona such as Cornellà de Llobregat and El Prat de Llobregat where there are almost the 23% of the working people of the region and the 20% of the companies.

The companies placed in the other part of the region is considerably lower, the centre of the Baix Llobregat has the 14% and the North the 15%, almost 2,500 each one.

Although the economical activity is consolidated in the delta, during the period 1996-2015 the biggest development, in terms of number of companies, have happened in the North with an average growth of 52%. In this sense, in the Figure 3.24 it is represented the variation in the number of companies during this period. It is remarkable that more than the half of the municipalities in the North have registered growth higher than 60%, more specifically, Abrera have the most important reaching the 87%. This phenomenon is directly related with the establishment of the Seat offices in Martorell, fact that increased the motivation of many auxiliary companies to place their factories in the nearby municipalities.

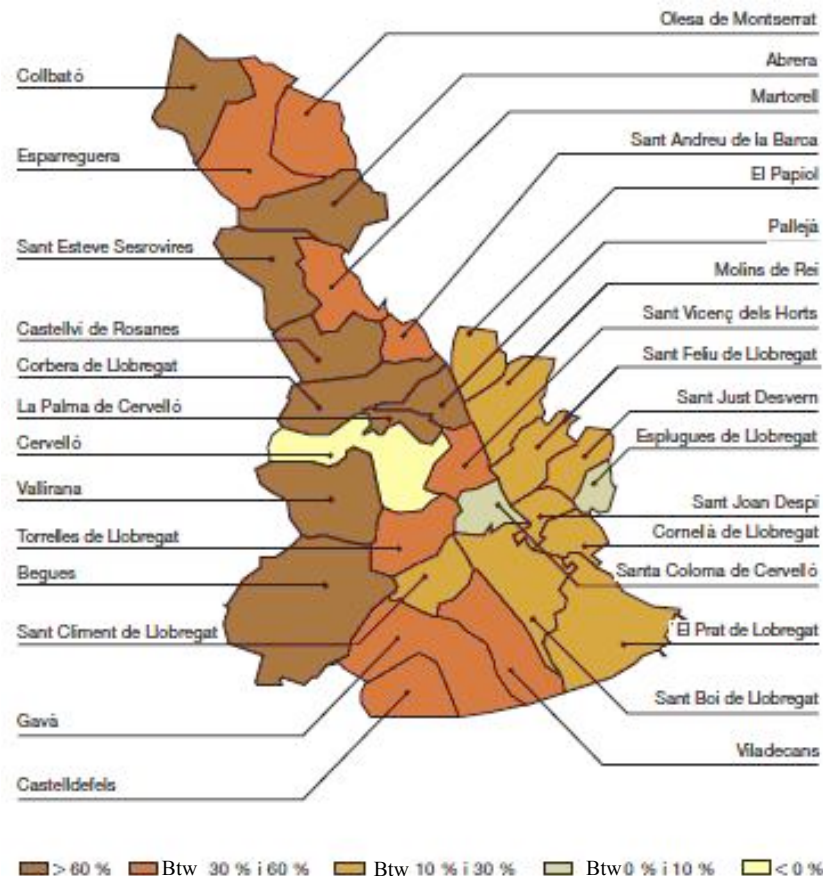


Figure 3.24. Variation of the number of companies in the Baix Llobregat (1996-2010). Source: Own elaboration with data from [5] and [7].

The price of the m^2 of land is one of the main factors that could explain the trend of the industry companies' establishment in the North of the region. If we compare Figures 3.24 and 3.14 it is easy to observe that the processes of residential and industrial localization have suffered very similar patterns, with steeper developments in the North and smoothers in the South.

In the region of Vallès Occidental it's clear the presence of two important industrial centers such as Terrassa and Sabadell that at the same time are the most inhabited cities and the area that contribute in a high percentage in the economic development of the region. Nevertheless, it does not monopolize the industrial sector of Vallès Occidental which growth has similar patterns than the Catalan one reaching the 35.8% of the regional GDP and it's distributed more or less in an homogeneous way between the municipalities in the South of the region and these named before.

Some companies choose this region to establish their offices due to its excellent geographic position and the continuous demographic growth that implies an increase of the active population of the area. We can found an important industrial fabric of small and medium companies, which gives to the industry of the area flexible and versatile characteristics adapting the offer to different types of demand and that has turned this zone into one of the industrial and economic motors of Catalonia.

It is important to remark the diversification level of the industry which have traditionally been textile until the 60's, but this sector just represents the 9.1% of the

GDP in the present. The metallurgy and siderurgy are the other important business area of the region (14.3% of the GDP[12]) and it's mainly placed in Terrassa, Sabadell, Sant Cugat del Vallès, Rubí and Castellbisbal. Furthermore, we could find the leading automotive, mechanic and electric industry in the Eastern side, placed in Montcada I Reixac, Ripollet and Barberà del Vallès.

The important industrial influence is reflected in the 114 industrial polygons that we could found in the region, the biggest concentration of these areas just below the Baix Llobregat, most of them placed in the influence zone of the project without taking into account the contribution of the two aforementioned centers.

According with the characteristic of the business network of the region, we could finally conclude that the surrounding area of the activities of the LIFE GAIN project is still having a permanent economic and industrial development, increasing its weight in the activity production on the region so the valorisation of the plant designed and the field test will contribute to impulse the economy of the area having positive effects and are actions in consonance with the development trends of the area.

3.2.2. Siderurgy

The Catalan siderurgy has seen a reduction in the number of employers in the last years because of the economic crisis and the decrease in the activity of the sector. LIFE GAIN project will help to revert this situation by creating new employment at a local level in a short term and it could be important for the development of the siderurgy in Spain and Europe if the local results are good enough to extend it through the whole territory in a long term.

According to the “Coyuntura Metalúrgica Catalana” [13] the positive trend of the production in the sector, trying to recover the negative effects of the economic crisis, will continue during the next years in Catalonia. The financial and raw material costs will not raise the level that it has in the present. Otherwise a smoother increment in the personnel costs could be seen during the 2017.

On the other hand the energetic costs are the ones that present the higher growth tax and soon will be the most expensive in the steel production. It could represent one of the most important disadvantages of the Catalan siderurgy sector.

The 16% of the Catalan siderurgy companies are placed in the region of Baix Llobregat. There are some companies that work with steel products in the sector, but there is just one steelwork company in the Catalan territory. It is place in Castellbisbal and is CELSA, the company involved in the project and the biggest Catalan business group.

CELSA is an important siderurgy group that has international influence in the sector; its factory in Castellbisbal was founded in 1957 and has a production capacity of 2.5 million tonnes per year diversified in different steel products. We can find two electric arc furnaces in the factory with more than 140 tonnes of capacity each one and two continuous caster, one with square section and the other with beam blank section.

To ensure the obtainment of raw material CELSA have some affiliated companies for the steel scrap treatment. The steelwork in Castellbisbal is just a part of the total CELSA group, which give employ to 7,000 people in Europe and has a total production 7,5 million tones, numbers that have been decreasing during the lasts years.

CELSA GROUP		2007	2008	2009	2010	2011	2012
Annual Sales	Million €	4.811	5.536	3.463	3.962	4.723	4.437
Annual Sales	Million Tn	8.6	8.3	8.3	7.4	7.6	7.5

Table 3.7. CELSA Production. Source: [14].

Nowadays the company has important debts (2,700 million €), which is difficult to solve in the present since in other economic situation the company would solve the problem without doubt. Due to the minor impact of the construction sector and the continuous growth of China's companies with cheaper materials the European steelworks activity have been decreased.

At the same time the siderurgy industry of electric arc furnace established in Catalonia, which is practically CELSA, generates a 360,000 tonnes of slag from the production process of the Steel. This is an important amount of waste that should be sent to landfills, but with the proposal of this project we will be able to carry out the valorisation of the waste product turning it a benefit for the society and the environment.

3.2.3. Infrastructures: mobility and industry

Mobility of Baix Llobregat

When we analyse the regional mobility in the metropolitan area of Barcelona, the regions of Baix Llobregat and Maresme are the areas with the higher negative ratio attraction/generation. It could reflect a possible character of residential area for the people whose job is in Barcelona.

On the other hand, if we break down by municipalities the total number of trips, we will see some important differences between the North and the South part of Baix Llobregat. In the delta there is a significant predomination of trips out of the municipality, having a significant amount of trips with negative values in the ratio said before. This mobility is essentially in the direction of Barcelona because of the closeness and the socio-labour dependency, just El Prat the Llobregat shows positive values due to the establishment of the airport and many industry companies.

If we pay attention to the ratio attraction/generation in the North, we will realize that the results are completely opposites. It has positive values that mean bigger attraction than trips generation out of the area, acting as mobility focus. This fact is especially remarkable in the municipalities of Abrera and Martorell where there are bigger industry, services and trade centers.

The intermunicipal intraregional mobility represents a 41% of the trips inside the Baix Llobregat. In the figure below we could see in a schematic way the distribution in the

territory of the main intermunicipal relations of mobility. The most remarkable aspects are:

- The highest relations are in the placed in the South, especially the most important is that one established between Viladecans-Gavà with a total amount of 3,527 trips per day.
- In the North the main relation between municipalities is Martorell-Sant Andreu de la Barca with 1,581 trips per day.
- Martorell is the main attraction focus of mobility in regional terms since there are 8,638 daily displacements to this municipality. Cornellà and El Prat de Llobregat are the next ones with 7,901 and 6,814 trips respectively. In the Figure 3.25 it is possible to observe that the attraction of Martorell is not only from the North, it also have a significantly effect in Southern municipalities such as Sant Boi or Cornellà.
- Cornellà de Llobregat and Sant Boi, which are the biggest municipalities in terms of population, are the areas with the highest amount of generated trips reaching more than 8,000 per day.

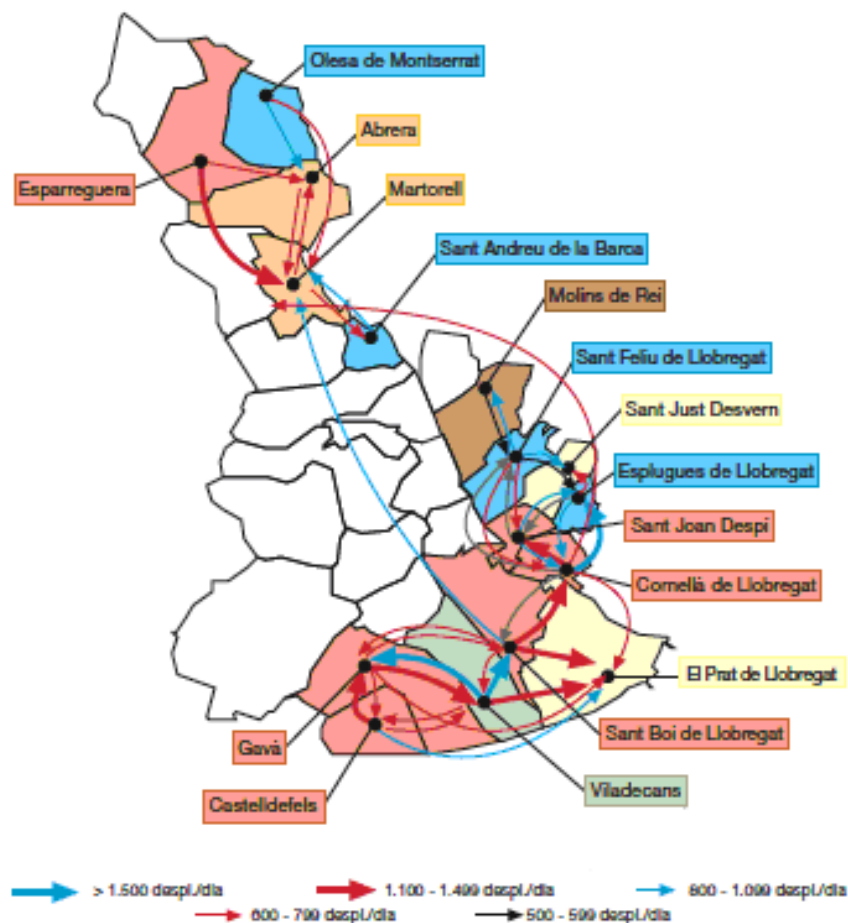


Figure 3.25. Interurban mobility exchange in Baix Llobregat. Source: data from [7] and [15].

We can complete this brief mobility analysis presenting in the table below the relation of the intraregional trips. Dividing the area in the zones it is possible to see that the displacements inside every area are higher than these ones between two of them.

Origin\Destination	South	Centre	North	Total
South	125,765	5,222	7,046	138,033
Centre	5,620	19,299	2,297	27,216
North	2,176	1,049	31,303	34,528
Total	133,561	25,570	40,646	199,777

Table 3.8. Intraregional trip exchange between the different subdivisions. Source: [15].

The data presented allow us to conclude that the highest volume of work displacements are in the Southern area but it also have an important contribution with the total amount of trips towards the North, this area generates almost two times more trips than the attraction that it has. On the other hand, the Northern region is the only one that attracts more people than these ones which goes out of the area while the centre is the region that has the lowest ratio of self-containment (percentage of inhabitant that live and work in the same area).

In the Figure 3.26 is presented the distribution of the interregional trips with origin and destination of each area of the Baix Llobregat, it has similar patterns with the intraregional mobility, the South and the Centre still having more generation (110,623 trips) than attraction (61,189 trips). The North is the only one that has more attraction from other regions than trips generation with a positive balance of 9218 trips.

According to the data of the obligatory mobility survey of the metropolitan area of Barcelona, we could establish the next mobility relations between the region of Baix Llobregat and the rest of the metropolitan area. It is clear that the trips generation is bigger than the attraction and the most important relation is logically with the Barcelonès (81% of the displacements).

There is another significant mobility exchange with the region of Vallès Occidental (12% of the displacements), which could be so interesting for the project purpose. It is clear that the transport network and the geographical proximity are factors that affect the mobility flux. In this way, the North and the centre of the region are the areas where the trip exchange with the Vallès Occidental are higher, reaching the 21% of the trips while just the 60% goes to Barcelona and the 19% left is the exchange with other regions such as Anoia. Likewise, Barcelona is the destination of almost the 90% of the trips generated in the South.

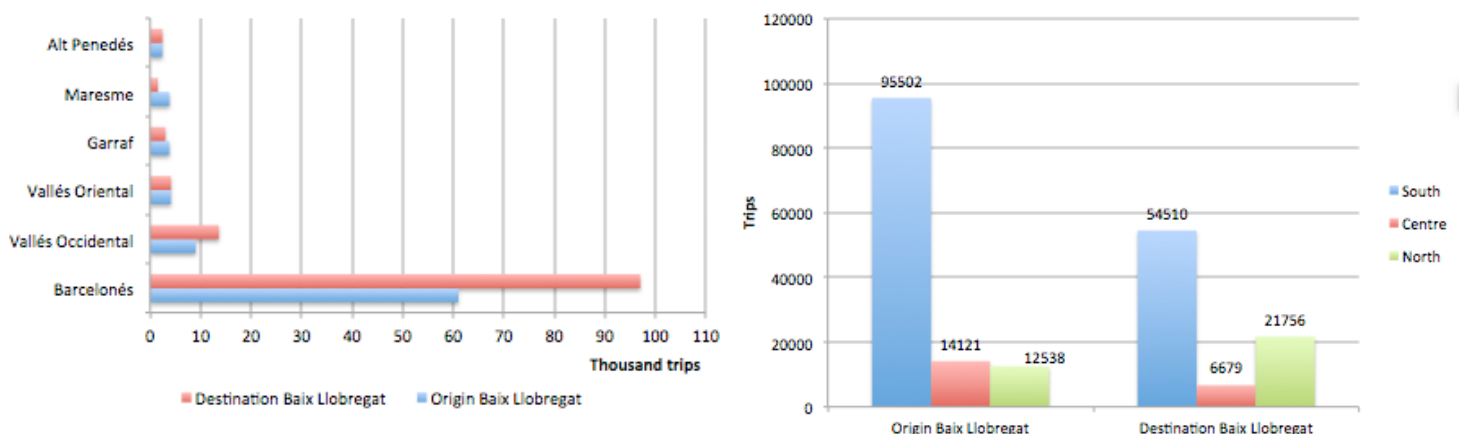


Figure 3.26. Interregional mobility of Baix Llobregat with the metropolitan area. EMO2011. Source: own elaboration with data from [15]

Mobility of Vallès Occidental

In the region of Vallès Occidental there are two important focuses of trips attraction (Terrassa and Sabadell), but in this analysis we just pay attention to the municipalities included in the influence zone of the project since its activities will not affect significantly the mobility of Terrassa and Sabadell.

First of all, the population of Castellbisbal is doing 13.600 trips per day, almost a 60% of these are inside the municipality while a 37.5% are out of the area. The main destinations of the outside trips are Barcelona (19.58%), Martorell (11.5%), Rubí (9.2%), Sant Andreu de la Barca (9.1%) and Terrassa (7.1%).

The figure below allow us to denote the importance of the mobility exchange of Castellbisbal and the rest of the influence zone since nearly a 45% of the outside displacement have the destination inside the area studied. A high percentage of the people who live in Castellbisbal have to move themselves to Baix Llobregat in order to work, so that the actions and the valorisation activities carry out in the region could affect significantly to the population of Castellbisbal.

Destination	Habitants	
	Trips	Percentage
Barcelona	2,687	19.8
Martorell	1,568	11.5
Rubí	1,245	9.2
Sant Andreu de la Barca	1,244	9.1
Terrassa	963	7.1
Main municipalities	5,020	36.9
First metropolitan crown	2,363	17.4
Second metropolitan crown	1,751	12.9
Out of metropolitan area	1,778	13.1
Total	13,600	100.0

Table 3.9. Iterregional mobility of Castellbisbal. Source: [16].

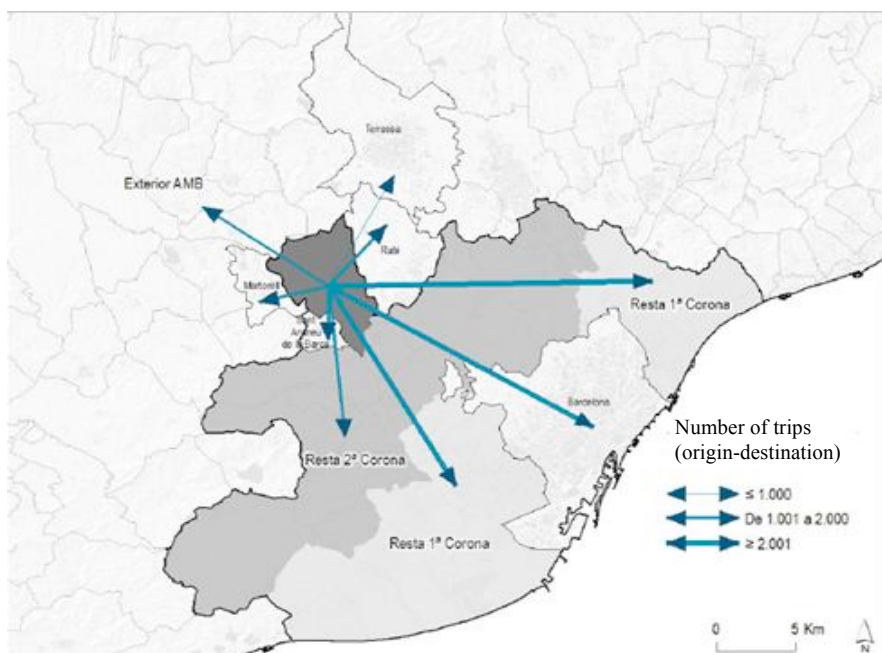


Figure 3.27. Interregional mobility of Castellbisbal with the rest of the metropolitan area. Source: [16]

The occupational mobility have suffer a smoother increment during the period 2001-2015 of 4,4% and the municipal self-contention is 49.1%, 6.2 points lower than fifteen years ago, fact that reflect the increasing interregional mobility in the present.

With regards to Sant cugat del Vallès, as it is said before, in this municipality the residential areas are predominant in the territory and it turns into a higher number of displacements during the day reaching four times more occupational trips than Castellbisbal and having a self-contention of 62.3%.

In this case it happens something similar to the previous situation where Barcelona is the main destination of the trips and the rest is divided in two clearly different groups. The first one composed by the inhabitants travelling in the East direction to Cerdanyola del Vallès, Montcada i Reixac and the industrial polygons in the surrounding area, which rises to the 11% of the displacements. On the other hand, these people who go to the West, where we found municipalities such as Rubí, Castellbisbal and the region of Baix Llobregat that reach the 13% of the trips.

Talking about Rubí, it is a municipality where the population is so high, with large residential area but also with an important percentage of industry so that the degree of self-contention is 62.68%. The inhabitants of the area make 3.51 trips per day but just the 44.7% of these are occupational and only the 17% is related to job. Despite these numbers Rubí has a positive ratio of attraction/generation, making this area one of the most important of the Vallès Occidental in industrial terms.

It is necessary to remark the significant relation between Rubí and Castellbisbal since the exchange of workers of both municipalities is continuously rising, making this relation the second one with more trips just below Barcelona and overpassing the 9% of the work displacements.

	Vallès Occ.	Baix Llob.	North	Centre	South
Trips inside	27,474	187,087	10,386	24,934	48,910
Trips outside	31,203	142,645	12,768	45,796	109,926
Trips from outside	36,568	97,307	27,952	31,157	71,219
Total generation	58,677	329,732	23,154	70,730	158,836
Total attraction	64,042	284,394	38,338	56,091	120,129
Attraction/generation	5,365	-45,337	15,184	-14,639	-38,707

Table 3.10. Total attraction/generation ratio of the Catalan influence zone. Source: Data from [15] and [16].

In the summary table above it is presented the daily mobility data of the different area studied in the project, where the values corresponding to the Vallès Occidental is only about the three municipalities aforementioned.

We can conclude that the Baix Llobregat has a high amount of occupational trips which has mainly destinations outside the region producing an important negative attraction/generation ratio. It could be a negative aspect, giving to the region a residential behaviour for the people who work in Barcelona, but this opinion could change if we split up the data in three subdivisions of the territory.

In this way, we realize that every geographic zone presents completely different patterns. Moreover, is the South of the region the main responsible of this wrong idea since the North and the centre part have not such clearly behaviour like that.

Another result derived from the table is that all the areas of the influence zone (North, Centre and Vallès Occidental) have a clear trip attraction behaviour due to its economic and industrial activity that make positive the attraction/generation ratio, so the project actions go in consonance with the economic development trends of Barcelona and its metropolitan area helping to enhance the industrial activity of the area by creating new sustainable business lines.

Infrastructures in the influence zone

The transport infrastructures are an important factor that conditions the development of the mobility, It is a real fact that the municipalities placed next to a main communication axis have higher trips generation and attraction than other placed in a less well communicated areas. In this sense, it is interesting to study and define the transport network of the influence zone in order to conclude if the different activities of the project will find difficulties in this area or not. It can also help us to understand the mobility patters said before and plan, which is the best way to carry out the project actions to avoid transport problem or delays.

The main communication axis of the influence zone could be divided according to the direction that it has, particularly into parallel or perpendicular to the river. In the Figure 3.28 it is possible to see a scheme of these main corridors.

Analysing the area we observe the AP-2 that is a free highway which goes parallel to the river from Sant Feliu de Llobregat to El Papiol where it connect with the AP-7, another highway which is perpendicular to the river and that allow the communication

between the Baix Llobregat and the Vallès Occidental in one direction and the Penedès region in the opposite one.

The last important highway that we find in the area is the A-2 which goes parallel to the river through the right side and cross all the region from North to South linking the municipalities of Esparraguera, Martorell, Sant Andreu de la Barca, Pallejà, Sant Vicenç dels Horts and Sant Feliu de Llobregat and helping to increase the mobility flux of this area in direction to Barcelona.

Another road that could have a significant role for the purpose of the project is the N-340, it is not a motorway, but it was the only option to link the Penedès region with Barcelona before the construction of the AP-7. It is a principal road, perpendicular to the river, which has been split up as the B-24, which cross the region through Vallirana and connects with the A-2 and AP-2 in the area between Sant Cugat del Vallès and Castellbibal. It could be interesting for this project because it links both companies involved in the project action and there are some quarries and landfills close to this road axis whose activity could be modified because of the recycling steel plant of the LIFE GAIN project.



Figure 3.28. Transport infrastructure in the influence zone. Source: [7].

There is an important focus of trips generation in the municipalities that are close to A-7 and A-2 such as Molins de Rei, Martorell, Sant Andreu de la Barca and Esparreguera. Otherwise, Corbera de Llobregat and Vallinara although are not the most inhabited municipalities neither have the best connection to the communication network, are in the top of the main trips generation municipalities due to its residential aspect and the low level of job offers.

If we pay attention to the railway infrastructures it is possible to see that the area is also well communicated in this sense since there are many railway lines of different gauge for both cargo and passengers such as the RFIG of Iberian gauge (Red de Ferrocarriles de Interés General), the RFIG of mixed gauge and the metric gauge network of the FGC (Ferrocarrils Generals de Catalunya). What means that it will not be an obstacle to share out by railway the final product once valorised to other national or international cities where it could be needed for the new construction, the renewal or the maintenance of rail tracks.

The project activities will generate a transport flux from CELSA to ADEC GLOBAL increasing the trips from Castellbisbal to Vallirana favouring the interregional trip exchange not only due to the slag transport, the new creation of job will also affect to this flux. Both municipalities are correctly linked by the motorway A-2 and the national road N-340 or its variant B-24, so it is supposed not to find any problem if the trip flux is increased.

As we describe in the previous chapter, this area is highly active in economic terms and the transport flux created could produce synergies with other companies of the industry sector enhancing even more the productivity of the municipalities.

3.3. Social diagnosis

It is undeniable the relation between the activity of a company and the society, since the 80's, some theoretical currents bet for a clear definition of the ideal relation between a company and the society where its activity is developed. It's important to establish a dynamic interaction with the different social agents, where its expectations and opinion are included in the company strategies.

Every day more, the weight of the intangible assets in the stock valuation of the companies is higher, prompting that the ethical and responsible actions begin to be present in the new company strategies.

In the last decades the weight of intangible assets, such as reputation, in the market value of the company has grown immensely, being today the most important factor in that assessment. For this reason, these elements must be present in any activity both strategic and operational levels.

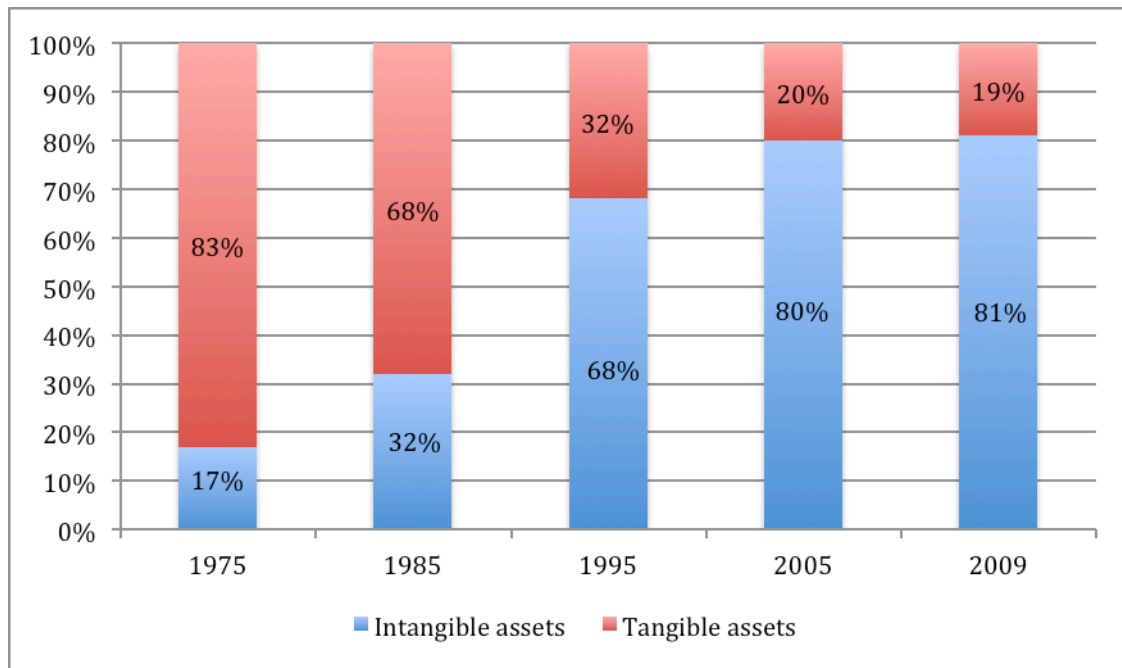


Figure 3.29. Components of the market value of the S&P 500. Source: Study carried out by [17].

This new approach to corporate governance seeks to ensure the economic sustainability of the company, linking it to the social and environmental sustainability of the activities that it carries out. To achieve this goal the initial point is the identification and analysis of their stakeholders such as the people affected or that may affect with their action the productive activity. Once analysed the possible aspects that could be affected by the project a communication channel with the population and the groups affected should be generated to know and respect its expectations and demands.

The information flows resulting from this new dynamics are very precious actives for the company since it will provide a higher sensitivity with the surrounding area, helping to anticipate risks and to get more profit from the opportunities that may arise. Intangibles such important and delicate as business reputation will be widely favoured with this approach, promoting greater harmony between the company and local communities.

A close relationship with the population will help and improve the management of the project, including the social and environmental risk. At the same time to take into account the opinion of the people will increase the social acceptance of the project improving both the project image and operative aspects.

In the case of the LIFE GAIN project three main areas are clearly affected by the project actions, which has an important impact on them. These three topics are, the Society, which include all the local population, active or non-active that will receive the project feedback and consequences, the Economy, which include the local productivity and industrial sector whose activity will be considerably influenced by the project, and the Environment of the surrounding area since it will suffer important changes.

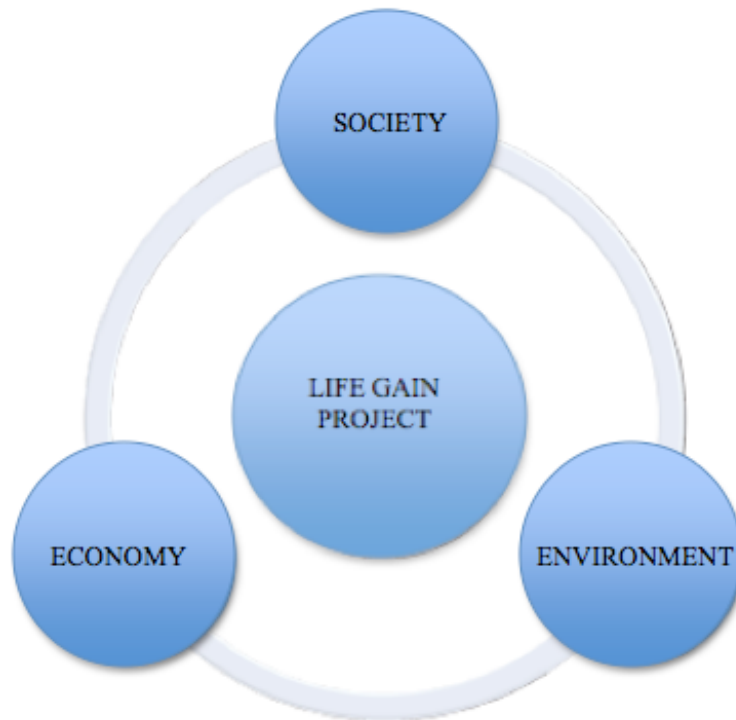


Figure 3.30. Affected areas of the LIFE GAIN project.

Once the territory, population and industrial sector, which are the scopes that could be affected by the project, have been defined, the next step is to collect their opinion and demands in order to evaluate the synergies with the project, the social acceptance that it has and if the transfer of information about the project is well defined. To achieve this objective we planned a qualitative analysis based on an anonymous survey about the main socio-economic impact of the project (general opinion about the project, the field test, the improvements derived from the project...).

The fact to be an anonymous survey and the informal approach of it has been planned to get a better communication flow with the population and collect more information.

The survey has been done to all age range population in order to have a representative opinion about the social acceptance of the project and the main problems and advantages that the population think that could be derived from the project actions. This will help us to take better decisions in the future actions and to evaluate all the work done until the present.

According to the results of the survey, the project has the acceptance of the 80% of the population (24/30 of the people asked). Although this high percentage of positive opinions about the activities of the LIFE GAIN, exist a small group of people who think that the project is not necessary for the actual society and that it's better to keep the traditional construction methods for such important transport as it is the railway. All the asked people with this negative opinion was older than 60 years old, what could indicate us that the old population do not approve such innovative project in this scope or that the widespread information about the project is not well defined to get the acceptance of this type of population and some changes should be done in the information disseminate methods.

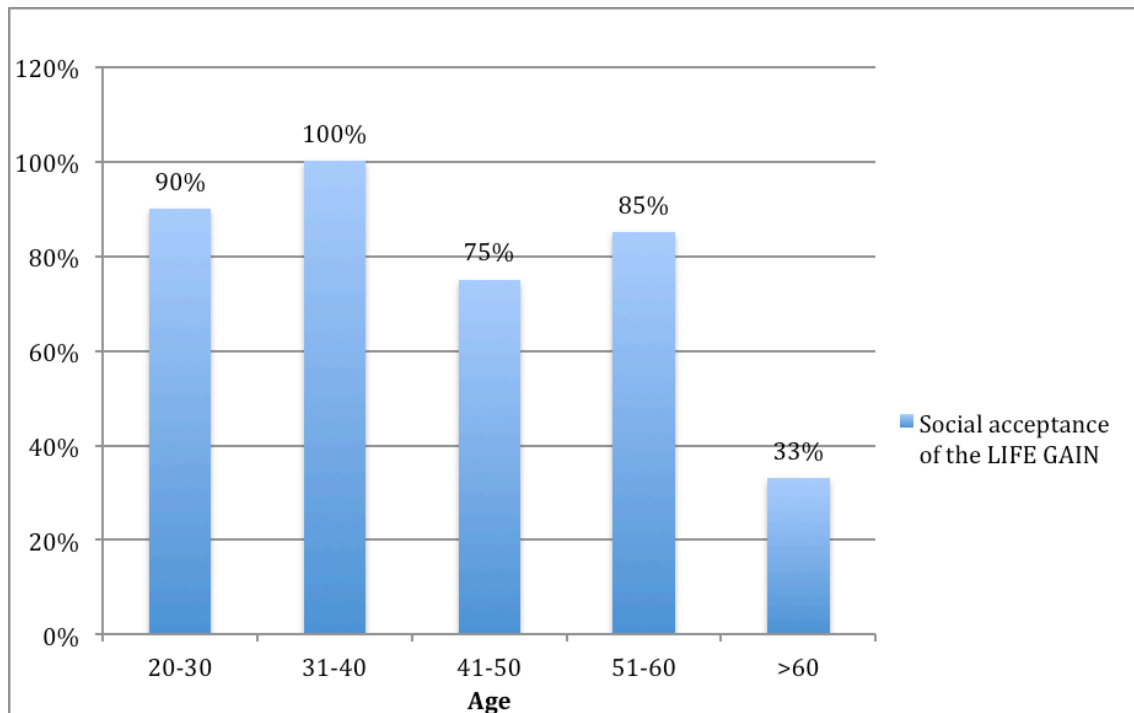


Figure 3.31 Social acceptance of the LIFE GAIN Vs age of surveyed people. Source: own elaboration.

Most people think that this project is an innovative approach since a new use for the SFS aggregate is develop and we are using the valorisation of waste material to substitute natural resources, which in a global warming context is an activity that helps to reduce the effect of this phenomenon.

Almost the 73% of the population think that the replication and transferability of the project results could be high enough to justify the investment needed, and that the project will not have just a local effect. The transfer of the technology applied along the whole territory could cause a global repercussion.

Another significant result derived from the survey is that the LIFE GAIN improve the image of the siderurgy sector at a local level and that the line of action is in consonance with the eco-friendly trends that are nowadays developed in most of the industrial sectors since every day more, the companies bet for the investigation and development projects to enhance their productivity. Just the 13% of the asked population think that the use of black slag will not be a benefit for the sector and that it would be better for the siderurgy to carry out project to try to reduce the amount of slag obtained from the steel production.

One of the things that satisfy almost the whole population is the construction of the field test. The 90% of the people think that the tests at a real scale are necessary to check the laboratory results and to ensure the correct behaviour of the SFS-RAIL in working conditions. Even the people who have a negative opinion about the project said that it is an important point of the project since it could affect to the travellers safety if there are some problems in the track with this new material, and the checking of the mechanical properties is one of the main actions that must be carried out.

After the explanation of the project objectives and other activities that COMSA are planning in the railway sector, the opinion about this type of transport change in a high

percentage of the surveyed people. Most of them have no idea about such innovative and eco-friendly activities in this sector and didn't know the energetic efficiency of the railway and the low level of CO₂ emissions that it has. It is due to that fact that the widespread information about this project positively changes the opinion of the inhabitants. Some of the surveyed people were usual users of this transport and have more information about some measures that have been carried out in this scope to improve the transport performance so that they already had a positive opinion about the railway before the introduction of the LIFE GAIN activity.

Regarding the concern that could produce the use of product valorised waste in a transport infrastructure, just the 10% of the respondents were afraid about the use of a waste product. This percentage match with the group of old people said above, which has a negative opinion about the project, the rest thought that this final product has to satisfy many regulations and that a lot of test were carried out before its direct application in the railway track, so that the level of risk will be low enough to ensure the same rate of possible accidents that if we use natural aggregates.

More than the 80% of the population see the slag valorisation as a positive activity for the local economy. They think that it could enhance the siderurgy sector of the region producing some economic benefits and that the jobs generated from the project activities will be positive to reduce the unemployment level of the area.

In social terms, the inhabitants of the affected area said that the measures taken in the project could produce positive results in the society since the reduction of the industrial waste and the quarries activity will suppose and improve of the quality of life of the population in the influence zone of quarries and landfills. In the same way, they consider that the investment needed for the project it is not so high in comparison with all the possible benefits that it could have in a short term if the results are good enough for its replication.

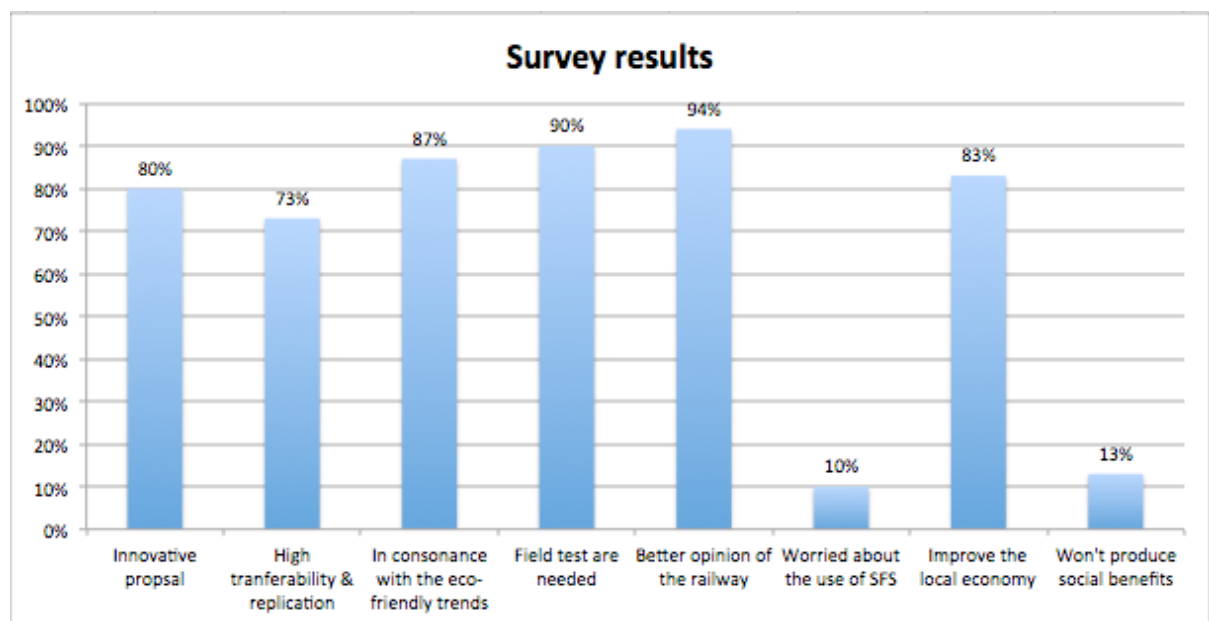


Figure 3.32 Results of the survey done to the population of the influence zone. Source: Own elaboration.

To sum up, we can conclude from this chapter that the social acceptance is high enough for the LIFE GAIN, there is a heterogeneous group of people from 18 to 60 years old,

who have a positive opinion about the project and think that the final results and its transferability could be so interesting for the future development of the railway transport, and bet for the slag valorisation aggregates as a construction method for the tracks and as a new possibility for the reduction of the landfilled industrial waste.

On the other hand there is another group of people older than 60, where not all of them, but a high percentage thinks that the project it is not interesting for the society and that we should invest the money in other type of projects. This negative opinion could be derived from the lack of information about the project activities or a wrong choice of the dissemination channels that may not transfer correctly the information to this population sector, so that maybe is necessary to provide more information through other methods to try to change this negative vision of some of them. Although this inconvenient, we have to remember that the 80% of the population is agree with the LIFE GAIN objectives and that is difficult to convince the whole population to support a project like this.

3.4. Siderurgy industry

3.4.1. Definition and delimitation of the siderurgy industry

The European siderurgy industry is one of the leaders of this sector in the world, it has an income close to 190 billion €, giving job to more than 360 million people and reaching a production of 200 million tonnes of steel per year. In the European Union we can find more than 500 of steel production plants that obtain high amount of waste. It is for that reason that is important to give new applications to these residual materials since its valorisation will reduce the cost of processing and sending the material to landfills.

Although in the last years, the activity of this sector has decreased due to the economic crisis, the steel production is still significant in the countries where the construction of high-speed lines is a priority.

The Spanish siderurgy industry is one of the most important steel producers of Europe, in 2011 was the third country in steel production of the European Union just below Italy and Germany and it is in the 15th place in the world ranking. This sector employs 60,000 direct workers and 20,000 more for the waste collection [18].

Steel and siderurgy industry are the base of the development and the economic growth in the country since it is a material with multiple uses and that could adapt its characteristics to different requirements just changing the combination of iron and carbon.

More than 450 million € are invested in the Spanish steel sector in machinery and installations to keep and improve the productivity in order to be competitive in the international markets.

In Catalonia, although there are many companies implied in this sector, as we said in a previous chapter, there is just one steelwork company (CELSA placed in Castellbisbal), which carry out all the steel production of the area.

In Asturias the steel industry is one of the most traditional in the region and has been, together with mining, one of the driving forces of industrial growth since the early 19th Century. This extended experience, combined with the high level of training of the industry's workers and the technological development of the processes and products, have allowed the region to become an undoubted leader for the sector in Spain. These facts attract the attention of many international companies such as ArcelorMittal from India and ThyssenKrupp or PMG Powder Metal from Germany.

The first one is one of the most important enterprises in the siderurgy sector and has the only one siderurgy factory in Spain where the integral production of Steel take place, it produce 5 million tones that is nearly a quarter of the national production. The other companies mentioned pay more attention to automotive and airport sector steel uses.

In this region of Spain the whole metal sector, especially the siderurgy sector, has a significant importance in economic an employment terms, with more than 1.200 companies, 24,000 workers and a turnover of more than 5,000 million € in total [19].

It has a solid base of suppliers of goods and services for the industrial activity and it is one the main area of siderurgy and metallurgy in Spain. The industrial harbours of Avilés and Gijón helps to increase the development of this sector with docks specialised in siderurgy traffic and solid bulk cargo.

Other factors that favour the growth of the siderurgy in this region is the industrial land available and the geographical situation, which is perfect to export the products to the European market.

3.4.2. Economic contribution

During the last year the siderurgy sector have suffered a change in its economic trend. It is possible to observe the first positive tendency in the sector since the economic crisis began. This economic growth in the siderurgy is partially due to the increasing number of vehicles and the development of the automotive sector but the most important sector in terms of steel demand is the construction and civil works, which caused a significant increase of 5.9% of the steel production.

On the one hand, it's true that the percentage of demand satisfied by the importations is every year bigger since the importations in the sector increase faster than the consume. In 2014 8.3 million tonnes were imported, exceeding a 9.6% the data of 2013. The highest amount of these imports of steel comes from the European Union but the percentage of the china contribution in this aspect is continuously growing in the lasts years attracting every day more Spanish steel demand.

On the other hand, the Spanish exportations are remaining in the same level since 2013, with a total amount of 9.9 million tonnes. The weakness of the economic growth in Europe and especially in France, which is our main client, have decreased a 2.2% the European union exportations while this number increase a 2.6% when we talk about non-European countries. With this data we can conclude that the total commercial balance is positive, with an income of 1,670 M € in the sector, but it decrease considerably respect the previous year.

	2012	2013	2014	Variation 14/13
Steel production (kt)	13,639	14,255	14,249	0%
Steel imported (kt)	7,753	7,605	8,335	9.6%
Steel exported (kt)	9,658	9,875	9,876	0%
Steel consume (ktpm)	874	889	956	7.6%

Table 3.11. Spanish steel production. Source: data from [20].

This production is not homogenous in the whole territory; it clearly depends on the location of the steel production plants. In the figure below the distribution of these factories in the country is presented.

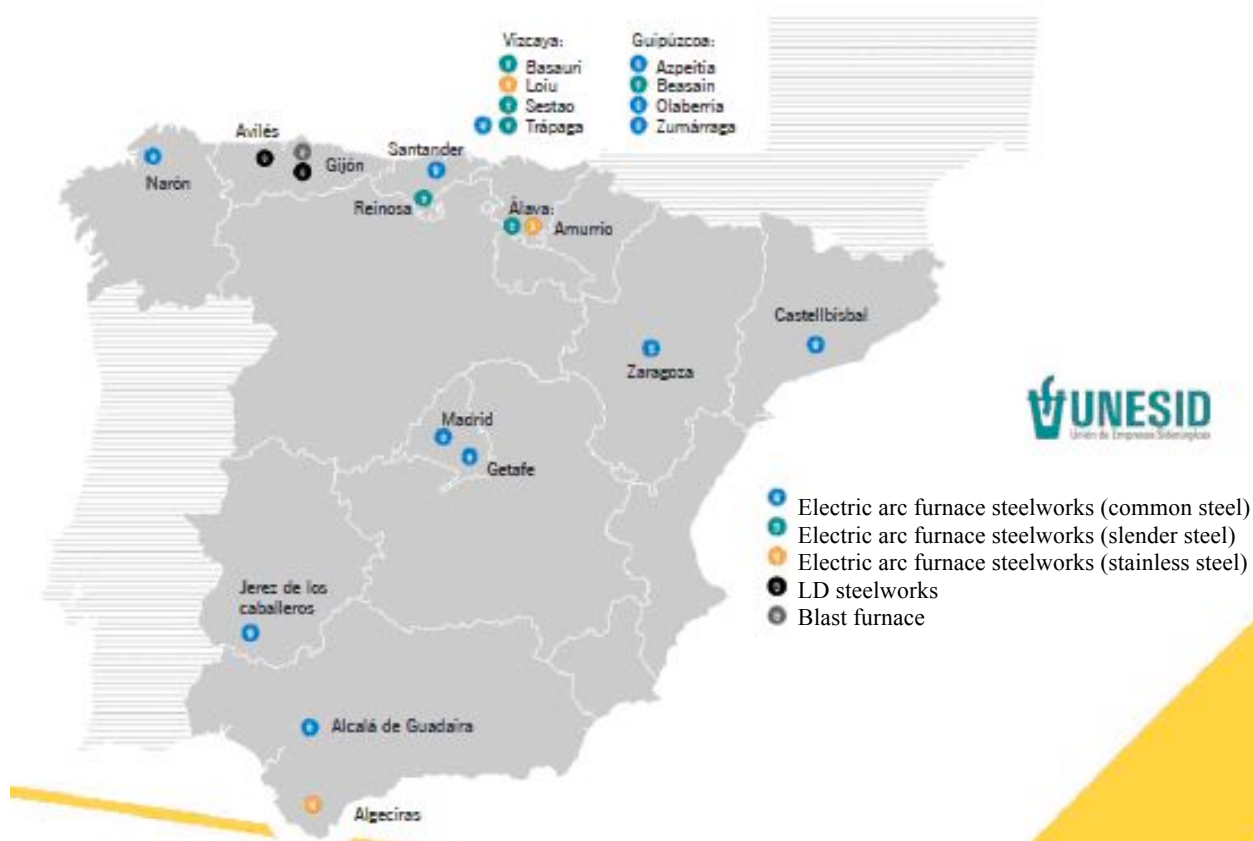


Figure 3.33. Location of Spanish steelworks. Source: [18].

These particular distribution sites in the North of Spain the higher percentage of the steel production, more specifically:

Basque Country: 35.6%

Asturias: 23.3%

Catalonia: 14.6%

From this data we can conclude that the siderurgy sector will contribute in an important way in the economy of the regions of Catalonia, the Basque Country and Asturias, where we can find more than the 70% of the total production.

Another characteristic of the siderurgy sector is that it is one of the main users of the transport network. More than 14 million tonnes of steel are produced during the year and the national and international distribution of the material and the obtainment of raw materials is needed. These facts make the sector, the main user of the railway cargo transport and generate more than 1.7 million operations by road.

In this sense, the transport costs are one of the most important costs of the annual balance of the industry and it is important to find the maximum efficiency in order to reduce it.

The Catalan metallurgy and siderurgy sectors have increased its activity an 8.5% during the year 2014 which also became in the creation of new employment. This positive evolution has been kept in 2015 in a smoother way. The financial and raw material costs are continuously diminished using new strategies that help to manage the siderurgy production. Nevertheless, salary, transport and energy costs are not in the same trend, and some companies have problems to manage it.

Are these last ones which presents the biggest growth tax, a significant amount of energy is needed for the steel production and it is one of the main disadvantages of the sector. Although this negative aspects the Catalan siderurgy increase its productive capacity, the investment in the sector and the self-financing in the lasts years.

Moreover, in the Asturian sector, the elaboration of metal products (not only steel) is the most representative of the production industrial sector and is the 11% of the GVA. The metal activity in Asturias implies the 26% of the industrial sector companies, concentrated the 38% of the turnover of the sector and the 43% of the industry employment in Asturias in 2013 [21].

During this year the activity of the sector increased a 2.23% as a consequence of the production of the siderurgy and metallurgy sectors along the year. In 2014 the volume of exportations of the sector represented the 66% of the regional exportations reaching the 2.5 million €.

It's clear that the siderurgy sector has a significant impact in the Spanish industry, especially in Catalonia and Asturias, and the project will help to increase development of the activity in these areas.

3.4.3. Siderurgy products and waste

Nowadays the main waste material of the siderurgy sector is the black slag which are currently produced in large amounts as a product derived from the steel production procedures. It is supposed that the total amount obtained in Europe of this material reaches 22 million tonnes, which represents a 12% of the total steel production. In the case of Spain, where the production of steel is close to 18 million tonnes, 2 million tonnes of black slag can be valorised per year. It is for that reason exists such a high number of studies about its composition, characterization and the possible applications that it could has in the civil engineering.

Steel production (Tn)	Slag generation (kg/Tn)	Total slag production (Tn)
200,000,000	Black slag 75%	22,500,000
	White slag 25%	7,500,000

Table 3.12. European steel slag production. Source: CEDEX [22].

Moreover, the composition of the black slag could slightly vary depending on its origin. According to CEDEX (Centro de Estudios y Experimentación de Obras Públicas) we can consider as representative values the percentage presented in the table below:

Fe ₂ O ₃	CaO	SiO ₂	MgO	Cr ₂ O ₃	FeO	TiO ₂
2-22%	27-37%	11-25%	4-11%	0.6-4%	3-25%	0.25-1.6%

Table 3.13. Black slag composition. Source: data from CEDEX [22].

Although this classification, other studies that take slag from different origin show the significant variation presented by the black slag.

Country\Element	CaO (%)	SiO ₂ (%)	MgO (%)	Al ₂ O ₃ (%)	FeO (%)	MnO (%)	P ₂ O ₅ (%)	S (%)
Japan	40	25	4	5	19	7	-	0.006
Sweden	46	11	5	5	28	4	0.7	-
EEUU	41	17	10	8	18	4	0.6	0.2
Germany	32	15	10	4	31	4	1.4	0.1
Brasil	33	18	10	6	30	5	-	-
Italy	41	14	8	7	20	6	0.9	0.1
Catalonia	31	14	5	9	27	4	0.35	-

Table 3.14. Variation of the slag composition depending on the production country. Source: data from CEDEX[22].

Taking into account the different values we realize that in the most representative elements such as CaO, MgO or FeO the variation is not negligible. It is important a well characterization of the slag in order to avoid some expansion problems produced by some elements presented in its composition which will limit the percentage of black slag that we can use in the civil works. These differences are mainly due to the raw materials used in the previous processes.

Some properties of this waste material are interesting for the civil work uses and justify the valorisation of the product. First of all the density of the black slag aggregates have high densities, close to 3.5 kg/l, which is a value considerably higher than 1,5 kg/l of the natural aggregates and the weathering test show lower values of LA coefficient (20-25%) that allow us to use it in the railway tracks.

The cohesion of the slag is practically zero once cooled and the values of CBR varies notably between 69 and 280 depending on the composition of the slag, but generally it presents higher values of the elasticity modulus respect to the natural aggregates with similar origin. These properties are good enough to satisfy the requirements to use the

slag in the foundations of rail tracks, but it is necessary to limit the amount of material placed in order to verify all the regulations.

Another fact that is important to take into account is that some leaching can be produced from the slag, and the pH of these liquids could be higher than 11, presenting some corrosive problems with other materials of the track such as the steel or the aluminium.

Paying attention to the application of the black slag, we realize that in the last years have been presented a lot of possible applications. The most remarkable are the uses of slag in aggregates for asphalt mixes, sub-base layers or aggregates for concrete in the road construction.

In the case of the road construction layers, the black slag satisfies the technical specifications of the regulation without any doubts. It can be used in different layers from the platform to the rolling layer, taking into account the possible expansion that it could produce in a long term.

This use is actually well extended in the world and although the railway tracks have different regulations and specifications it has been proved that the black slag could perfectly satisfy all the requirements and although there is no experience in Europe using this material in railway foundations, this new application presented in the LIFE GAIN project could present a lot of environmental, economic and technical benefits to the railway transport.

3.4.4. Siderurgy waste recycling

The Spanish siderurgy industry and particularly the Catalan one is place in the vanguard of the sector due to its environmental considerations. The efficient use of the natural resources such water or energy, the continuous reduction of CO₂ emissions and the waste valorisation are the main strategies of this industry in terms of sustainability.

In order to reduce the emissions of the global warming gases, the sector has established some important measures since 1970 that allow decreasing the CO₂ emissions per tonne of steel more than a 75% and a 50% in the last 20 years [18]. The 100% of the steel production is done using systems of environmental management and the siderurgy industry has invested more than 70 million € per year in environmental issues.

Almost the 100% of the waste and sub products of the production process are recycled or valorised by different ways. Slag is mainly used as aggregates in the road construction or cement production, and the investigation to expand its application is currently in development.

The siderurgy industry recycles many times the steel, in a permanent valorisation cycle where the properties and the quality of the steel are not deteriorated. This fact makes the steel the most efficient material since nowadays we are recycling material produced more than 150 years ago.

With a high technology process, the steelworks carry out this everlasting valorisation. It is the most recycled material in Spain reaching the 12.5 tonnes per year and, at the same

time, Spain is one of the main countries in terms of tonnes of recycled steel just after Italy.

It is important to distinguish between the steel recycling and the recycling or valorisation of the waste materials from the steel production which is the fact that results interesting for this analysis. As it was previously said, steel is one of the most recycled materials but one cannot say the same with the waste derived from its production, which pose a real environmental problem for the European Union. This turns into the accumulation of this waste in the landfills that requires large surfaces and into a lot of transport and environmental costs, that is the main reason of the continuous development of new technics of valorisation for this type of waste

This way, in order to obtain the aggregates from the slag, we have to apply a valorisation process which consist in some industrials procedures to guarantee that the final product comply with the requirements of the regulations.

First of all we have to wait until the slag is cool enough. This could be done by putting it in water in order to make a treatment to avoid future expansions due to the humidity.

After that, it is important to remove the impurities of the slag before to proceed with the sieving of the material. If the granulometry is not fine enough, it is possible to crush the slag until the obtaining of the right distribution.

To finish with this valorisation process we must carry out different tests to ensure that the properties of the final material are the correct ones.

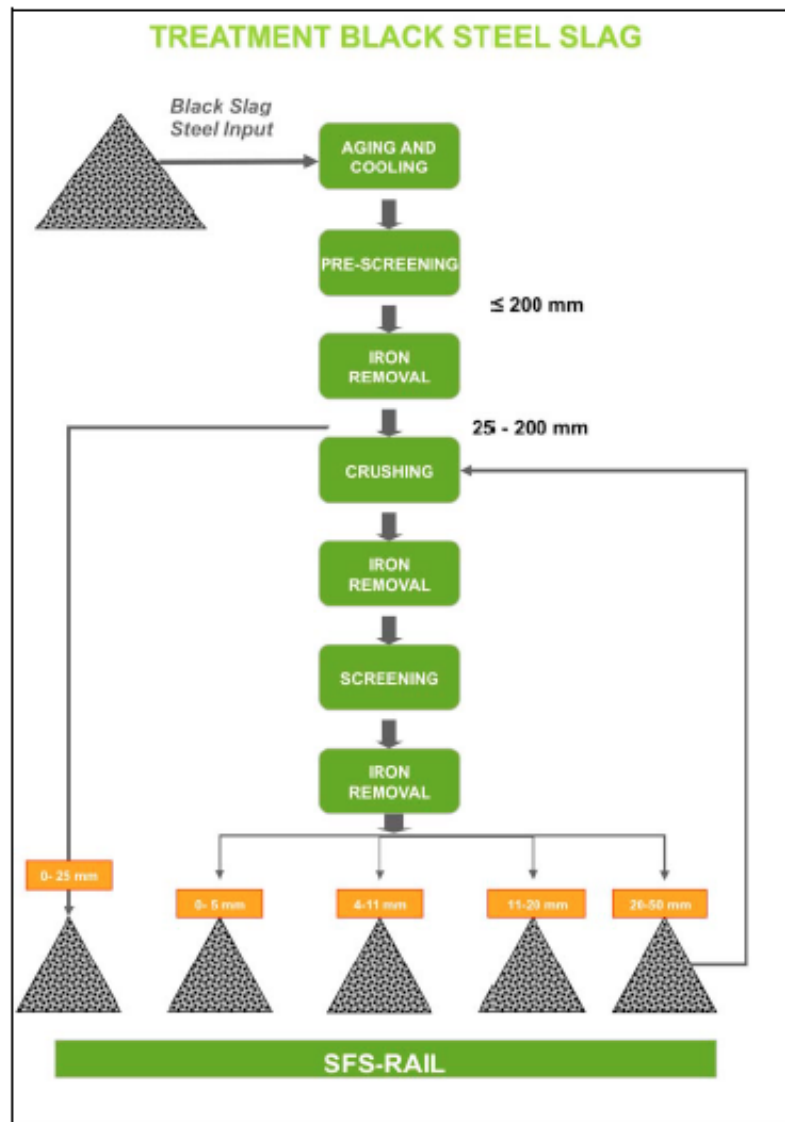


Figure 3.34. Slag valorisation process.

Given the huge production of this waste material, during the last few years, establishing a correct management of this kind of slag has been an important preoccupation of the researchers of the sector, who have been conducted to establish the potential use of slag in different activities. In Europe, the European association EUROSILAG, constituted by organizations and companies concerned with all aspects of manufacturing and utilization of ferrous slag products, deals with promotion of slag as a product, enables exchange of information and research as well as facilitates the interaction with governing bodies.

In order to reduce the significant volume of black slag, which was annually dumped several years ago, different alternative applications of this waste material have been developed in the past decades and are already being applied with success in several countries.

The deposit volume of slag in the year 2000 was considerably, specifically 4 million tonnes, but according to the last data published by EUROSILAG, referring to 2010, this rate of dumping has diminished to 2.9 million tonnes, but is much higher than in former years due to the economic crisis of the sector.

Although the slag sales are improving in Spain and the product is gaining acceptance in the civil engineering sector, the fact is that, according to CEDEX, to December 2007 only several pilot, small-scale and isolated applications using black slag as aggregate for different road layers had been carried out. Nowadays this application have increased but in a slightly way.

A good example of this reality is the outputs of ADEC GLOBAL. The company manages 100% of the EAFS annual production of the Spanish steel-producing company CELSA, which ascends to 360,000 tonnes/year, from which 280,000 tonnes/year are black slag. From July 2010 to date, ADEC GLOBAL has received 1.3 million tonnes of EAFS from CELSA, of which it retains a stock of 700,000 tonnes, because there is not enough demand of EAFS to satisfy.

Thus, it could be concluded that, nowadays, landfill disposal of slag is not such a big an generalised concern in the European Union, as it was in the past decades, but the final disposal rate could increase in the next years so the recycling and valorisation of this material with new applications and methods like the proposed in this project could capture the market share of minority uses of slag, or even part of the market share of the majority ones.

4. IMPACT OF THE SFS-RAIL PRODUCTION

4.1. Impact of the project

In this chapter we will analyse how the project actions and the field tests will affect in economic, social and environmental terms in the different aspects presented during the previous chapters such as the population, the local productivity and other activities of the siderurgy sector.

A general classification of the different impacts of the project have been done in order to analyse the consequences of every action or situation derived from the project activities, so that we are going to talk about i) the impact of the foreseen investment; ii) the impact of the steel slag recycling due to the increasing in the activity of the valorisation plant of ADEC GLOBAL; iii) the impact of the decrease in industrial waste since the valorisation of the slag cause a diminish in the siderurgy waste send to landfill; iv) the impact of the reduction of quarries activity because of the use of slag in the railway tracks; and v) the impact induced by the increase in employment, since all the project activities will generate new employment in a local level, where more qualified workers will be necessary.

In the table below it is presented a summary of the impacts aforementioned and its impact on the previous chapters of the socio-economic study in a qualitative way. It is possible to see which are the main aspects that every impact will affect and if its repercussion will be high (+++), medium (++), low (+) or will not produce any effect (-)

As it is going to be develop in the next chapters, the impact of the project investment and the increase of steel slag recycling will be focus mainly in the Local productivity while the decrease of industrial waste and the reduction of quarries activity will clearly affect in a steeper way to the territory and demography and to the social acceptance since are environmental issues that worry the population and affect to its opinion. In addition, the increase in jobs produced by the project and its potential extension includes all the aspects, so in an economic crisis context as the actual it is an impact that leaves no one indifferent.

	IMPACTS				
	Project Investment	Increase of steel slag recycling	Decrease of industrial waste	Reduction of quarries activity	Increase in jobs
Territory and demography	+	+	+++	+++	+++
Local Productivity	++	+++	+	++	+++
Social acceptance	+	++	++	++	+++
Siderurgy sector	+	+	++	-	+++

+++ High impact ; ++ Medium impact ; + Low impact ; - No impact.

Table 4.1. Summary table of the project impacts.

4.1.1. Impact of the foreseen investment

First of all is necessary to have an idea about the impact of the project investment. Usually we have a limited budget for project funding so it will be interesting to know which is the most profitable project to invest the funds. In order to do that there are some economic indicators such as Net Present Value (NPV), Internal Rate of Return (IRR) or the payback, which could help us to identify if it is a good option to bet for this project.

With this objective, all these indicators have been computed for the LIFE GAIN project. ADEC GLOBAL have an annual production of valorised slag of 216,000 tonne (number below 280,000 tonnes, the total slag production of CELSA) and almost the 46% of the production is currently sold to use it as road aggregates and many other applications of the slags described in the previous chapters.

The potential market of our project is the 54% of the ADEC GLOBAL's production that is not commercialized, so that the economic analysis and the indicators are computed taking into account a production and sale rate of 155,520 tonnes of SFS-RAIL, which will include 116,640 tonnes of slag ($216,000 \times 0.54$) and 38,880 tonnes of natural aggregate since the composition of the SFS-RAIL is 75% of slag and 25% of natural aggregate.

A previous definition of the cost and prices of the different materials, transport and initial investment is needed to understand easily the results obtained.

On the one hand, the initial investment of the project is defined in the financial information of the LIFE GAIN proposal of 2012, where the personnel and machinery cost to carry out the adaptation of the valorisations plant for the productions of SFS-RAIL amounts to 85,000 €. Taking into account the final impact that the project could have, it is easy to conclude that this is not a high amount of money in comparison with the expected economic benefits.

On the other hand, the costs for the production of one tonne of SFS-RAIL are described below:

- Cost of natural aggregate: 8 € per tonne of aggregate. It should be a particular type of aggregate since it must satisfy the granulometry and resistance regulations for the sub-ballasts layers. COMSA has many project in the railway sector and is in touch with companies that supply such aggregates like the necessary for the sub-ballast layer so that the price was obtained from SORIGUE, one of this aggregates suppliers company of COMSA.
- Cost of transport: 0.13 € per kilometre and tonne. The price of transport has a lineal behaviour until a hundred kilometres, from which, the price per kilometre decrease considerably, this is partially due to some cost that are fix and does not depend on the kilometres. In this way, and according to the data from ADEC GLOBAL and SORIGUE, the transport cost vary from 0.14 € (from 0 to 10 km), 0.13 €(from 10 to 20 km), 0.12 € (from 20 to 40) and 0.08 € if it is a long trip.

- Cost of valorisation process: It is not a fix cost since it depends on to many factors like the total production and demand of the material, the machinery of the plant, and all the procedures that must be carried out for the valorisation of the material. ADEC GLOBAL gave us an idea of a oscillation range of this cost, and improving the efficiency and the performance of the machinery and the employers during the different procedures of the valorisation process we can get a value of 1,2 € per tonne of valorised material.

Once described all the cost of the SFS-RAIL production we fix the final price of the product that will be close to 5 € per tonnes, a price considerably below the natural aggregate one, fact that will help us to design a competitive material in economic terms and to have important economic and environmental savings.

We proceed with the computation of the different parameters taking into account a discount tax of the project for the NPV of 5 %, a reasonable number for a project o these characteristics. Another hypothesis derived from previous studies and goals of this socioeconomic analysis is that the production of slag will increase every year during the next five years after the data of the analysis; this increment is not uniform and varies from 5 to 10%.

INITIAL INVESTMENT	UNIT PRICE	QUANTITY (kTN)	COST
Plant adaptation cost (k€/tn)			85.0
PRODUCTION COST			
Transport (€/tn/17km)	2.2	116.6	256,600
Valorisation process (€/tn)	1.2	116.6	139,900
Natural aggregate (€/tn)	8	38.9	311,000
		TOTAL	707,600
PRODUCTION BENEFITS			
SFS-RAIL price (€/tn)	5	155.5	777,600
Discount tax	0.05		

Table 4.2. Initial investment, production cost and benefits of the project.

	2016	2017	2018	2019	2020
Total incomes (k€)	777.6	800.9	840.9	899.8	989.8
Total cost (k€)	707.6	728.8	750.7	773.2	796.4
EBITDA (k€)	69.9	72.0	90.3	126.6	193.4
Beneficio tras impuestos (25%) (k€)	52.5	54.0	67.7	94.9	145.1

Table 4.3. Annual benefits of the project.

NPV (k€)	264.3
IRR	70%
Payback (years)	1.5

Table 4.4. Economic indicators of the project

After the computation of the indicators it is possible to have an idea of the possible project outcomes. According to the results obtained, the payback will be just 1,5 years, what means that you will recover the initial investment of the plant adaptation process in 18 months, with benefits for the company higher than 50.000 per year, reaching the 145.050 € in 2020 when the production of the SFS-RAIL will be significantly increased and the replication of the project will be higher.

In addition, the Net Present Value of the project is 264,277 €, which is indicating us that the project will generate gains above the profitability required. The last indicator, the IRR, gives us an idea about the profitability of the project. In this case is a 70%, which is a value much higher in comparison with the projects that have been carried out. This fact could be due to the low initial investment that we have to do for the adaptation of the plant and the incredible benefits that we could produce just by modifying an existing plant. This will be different if the construction of a complete valorisation plant will be needed, where probably in this scenario the results obtained will be completely different, and the obtainment of gains will be much more complicated in such short period of time.

Other important impacts of the investment of the project are the social and the environmental benefits that the project could produce if we decide to develop it. In order to know which are the benefits for the society and the environment, the comparison between the natural aggregate solution and the LIFE GAIN proposed solution have been carried out analysing the savings that it could produce in terms of CO₂ and economic savings.

The distinction of the potential impact of the project and the impact of the test sections has been done to know how they will affect at a local level.

The savings for the society has been computed comparing the social cost of the natural aggregate solution and the proposed one. On the one hand, if we choose the natural aggregate solution we have to take into account that we will pay an additional cost of the slag transport to landfill since without its valorisation, it will continue being a waste material. Otherwise, if we choose the other solution the only cost for the society will be the final price of the SFS-RAIL from ADEC GLOBAL that will be considerably lower than the natural aggregate, so it will save money.

In the table below are presented the calculations done assuming that the closest landfill is 20 km away from the slag. In this sense, the difference between both solutions, taking into account the same potential production previously exposed, is 772,233 € per year, which is a significant amount of money comparing with the investment needed for the project, and another evidence of the high value of profitability (IRR=70%) obtained before. These high potential savings and the transferability of the project could be an important boost for the local productivity in the initial period of the project.

SOCIAL BENEFIT	UNIT PRICE	QUANTITY (TN)	DISTANCE (KM)	COST
NATURAL AGGREGATE SOLUTION				
Cost of natural aggregate (€/tn)	8	155,520		12,441
Slag transport to landfill (€/tn/km)	0.13	116,640	20	303,264
Cost of slag lanfilled (€/tn)	0.02	116,640		2,409
			TOTAL	1,549,833
GAIN SOLUTION				
Final Price of SFS-RAIL (€/tn)	5	155,520		777,600
			TOTAL	777,600
			Savings	772,233

Table 4.5 Social benefits of the potential production.

Proceeding with the same calculation for the test section we realize that the impact of this will not be as big as the calculated before but it could have importance at a local level, where the properties of the rail track have been improved with this solution, the renovation of the track have been carried out and a savings of almost 5.000 € have been obtained doing this renovation process in just 200 meters of track (100m in Castellbisbal and 100m in Gijón).

We can conclude from this data that we will get some important savings per km of track (approximately 24.000 €/km) using this innovative solution and that the final repercussion of the LIFE GAIN could be high enough to bet for this project and extend the project results to whole Europe helping to mitigate the negative effect of the high amount of black slag that are daily send to landfills.

SOCIAL BENEFIT	UNIT PRICE	QUANTITY (TN)	DISTANCE (KM)	COST
NATURAL AGGREGATE SOLUTION				
Cost of natural aggregate (€/tn)	8	1,000		8,000
Slag transport to landfill (€/tn/km)	0.13	750	20	1,950
Cost of slag lanfilled (€/tn)	0.02	750		15.495
			TOTAL	9,965
GAIN SOLUTION				
Final Price of SFS-RAIL (€/tn)	5	1,000		5,000
			Savings	4,965

Table 4.6. Social benefit of the field tests.

What about the environmental cost of both solution for track construction and renovation that we are analysing, it has been computed taking into account the equivalent CO₂ emissions of the different procedures of each solution. Once that we have the total CO₂ emission savings, it is easy to turn it into economic savings using the price of one tonne of CO₂ emissions obtained from SENDECO₂ [23].

The tonnes of CO₂ emitted by the different activities of the project have been obtained from the LCA of this project, a previous analysis done by the company. It is supposed that the landfill is place in an average of 20 km from the steelwork and an average distance of 40 km of the civil work or track renovation from the quarry and 60 km from the valorisation plant. This difference in the average distance of the civil work from the quarry and the valorisation plant is due to that actually there are more quarries than valorisation plants of black slags, and the possibility of having a quarry closer is higher than have a valorisation plant. This longer distance could be reduced in the future if more valorisation plant are established so the potential savings of the GAIN solution could slightly increase if it happens. The transport has an important economic and environmental cost so the distance to the quarry or the valorisation plant could be important enough to choose one or the other solution.

The results of the table below show how considering the different procedures implied in the natural aggregate solution, a total amount of 883,584 tonnes of CO₂ are emitted per year. This is a value significantly higher than the presented for the alternative, where the final value is reduce to 411,700 tonnes of CO₂, this fact is mainly due to the difference in the emissions per tonne of natural aggregate extracted (2,576 tonnes) and tonne of SFS-RAIL produced (0.151 tonnes), since the transport is needed in both cases and the impact of the slag landfilled is considerably lower than the other ones.

Although the GAIN solution also needs the extraction of natural aggregate, the difference in the tonnes extracted (25% of the total) marks the difference in the final emissions.

ENVIRONMENTAL COST	UNIT PRICE	QUANTITY (TN)	DISTANCE (KM)	CO ₂ emissions (TN)
NATURALAGGREGATE SOLUTION				
CO2 from aggregate extraction (tn CO ₂ /tn)	2.576	155520		400,619
CO2 from slag transport to landfill (tn CO ₂ /tn/km)	0.027	116,640	20	62,985
CO2 from aggregate transport (tn CO ₂ /tn/km)	0.027	155,520	100	419,904
CO2 from slag landfilled (tn CO ₂ /tn)	0.000644	116,640		75
TOTAL				883,584
GAIN SOLUTION				
CO2 from the valorisation process (tn CO ₂ /tn)	0.151	116,640		17612,64
CO2 from aggregate extraction (tn CO ₂ /tn)	2.576	38,880		100,154

CO2 from slag transport (tn CO ₂ /tn/km)	0.027	116,640	60	188,956
CO2 from aggregate transport (tn CO ₂ /tn/km)	0.027	38,880	100	104,976
TOTAL				411,700
Savings of CO₂ tn	471,883			
Economic saving (€)	2,680,300			

Table 4.7. Environmental benefit of the potential production.

With the hypothesis explained above, it is possible to reach a total saving of 471,883 tonnes of CO₂ per year, which represents almost 2.5 million € taking an average price of the CO₂ tonne of 5.68 €. This is the representative value of 2016, but the price have had an important fluctuation during the last years, varying from 22 € per tonne in 2008 to 4 € in 2013, so the final economic savings could be directly affected by this variation.

If we pay attention to the field test, in this environmental area we could see how the tonnes emitted with the natural aggregate solution in the 200m almost double the data of the other one. This could represent important saving per kilometre of track construction/renovation if we finally choose the LIFE GAIN option. 750 tonnes of slags has been valorised and 250 tonnes of aggregate has been extracted for the construction of the field test, with total emissions of 2,647 tonnes of CO₂. On the other hand, if the track renovation would has been carried out with the standard solution the value of tonnes would increase up to 5,681.

ENVIRONMENTAL BENEFIT	UNIT PRICE	QUANTITY (TN)	DISTANCE (KM)	CO₂ emissions (TN)
NATURALAGGREGATE SOLUTION				
CO2 from aggregate extraction (tn CO ₂ /tn)	2.576	1,000	1	2,576
CO2 from slag transport to landfill (tn CO ₂ /tn/km)	0.027	750	20	405
CO2 from aggregate transport (tn CO ₂ /tn/km)	0.027	1,000	100	2700
CO2 from slag landfilled (tn CO ₂ /tn)	0.000644	750	1	0,483
TOTAL				5681,483
GAIN SOLUTION				
CO2 from the valorisation process (tn CO ₂ /tn)	0.151	750	1	113
CO2 from aggregate extraction (tn CO ₂ /tn)	2.576	250	1	644
CO2 from slag transport (tn CO ₂ /tn/km)	0.027	750	60	1,215
CO2 from aggregate transport (tn CO ₂ /tn/km)	0.027	250	100	675

	TOTAL	2647
Savings of CO₂ tn	3,034	
Economic saving (€)	17,234	

Table 4.8. Environmental benefit of the field tests.

In this case a local savings of 17,234 € have been obtained just using the slag valorisation along the 200m mentioned. Once more, this data indicate us that such a good solution like this in environmental and economic terms, should have an important transferability in the railway sector, helping to increase the future impact of the project in the different industrial sectors implied.

These positive results of the project impact and all the potential saving that can be produced will increase the social acceptance of the project since nowadays there are many environmental awareness campaigns and the people and the global warming its an important issue that worries the population.

4.1.2. Impact of the increase of steel slag recycling

In this chapter we are going to try to analyse the impact of the increase in the steel slag recycling due to the activity of the ADEC GLOBAL plant in Vallirana. The increase in the activity of the company will clearly have an important impact in the local productivity since it will raise, and the economic development of the area will be improved during the next years after the implementation of the project.

The maximum amount of slag available for the valorisation is the annual production of CELSA that reach the 280,000 tonnes per year, but this number is limited for the production capacity of ADEC GLOBAL, that nowadays is generating 216.000 tonnes of valorised product. Since 2010 until the present, the company has received 1.296.000 tonnes of slag, selling 596.160 tonnes to apply it in its different uses, and generating and stock of 699.840 tonnes of valorised slags.

With this data it easy to see that ADEC GLOBAL have obtained significant gains during the last years with the valorisation of slag for its roads use, and it could be increased in the next years with the commercialization of the SFS-RAIL since it will raise the demand of slag. This growth of ADEC GLOBAL will favour the economy of the area and the local business network, especially the industrial and siderurgy sector, could suffer an important development.

Moreover, in one kilometre of track there are 5.000 or 2.500 tonnes of SFS-RAIL in the sub-ballast layer depending on the type of track (single or double), so that with the existent stock we can carry out the renovation of 186-373 kilometres of railway track generating savings of 737.762 tonnes of CO₂ that represents 4.190.490 million €. The social benefit of this action will rise up to 4.633.402 million €, since the cost of the railway aggregate will decrease, thing that without doubt will contribute to the social acceptance of the project as it is shown in the previous survey presented in the analysis.

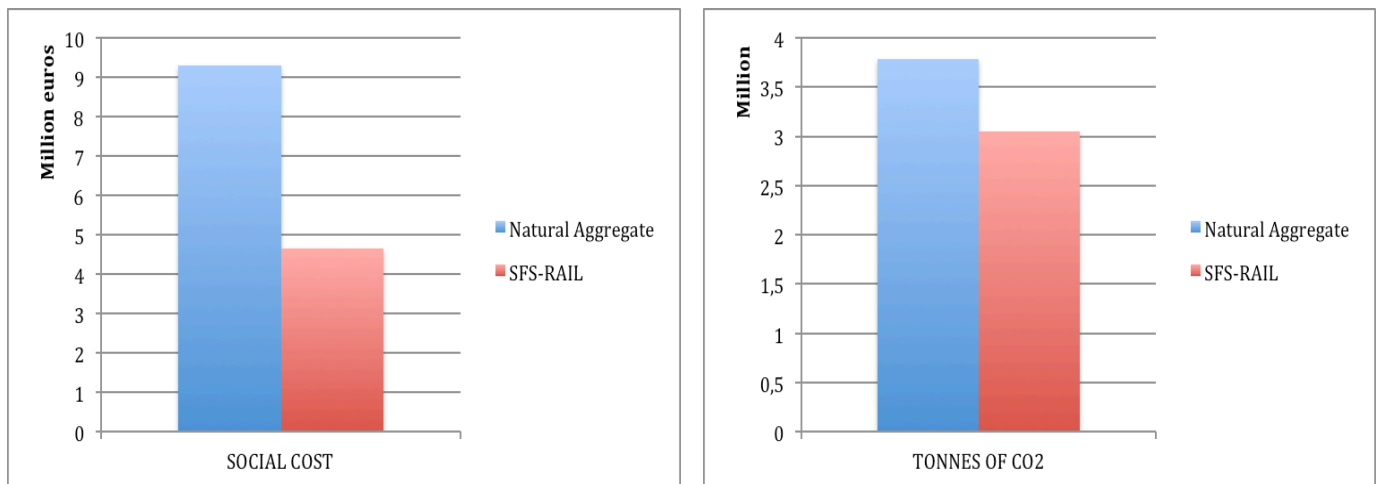


Figure 4.1. Comparison of social cost and environmental benefit between both alternatives.

The production of the company will generate a new type of aggregate for the sub-ballast and sub-grade layer of the railways tracks, improving the track geometric parameters, the resistance of the track and reducing the maintenance cost of it. All these facts are consequences of the slag valorisation and it is another thing for which the people think that it is interesting for the society and the environment to bet for this project.

With the project activity some synergies between CELSA and ADEC GLOBAL will be created since the establishment of the industrial relation will have consequence such as the increase of traffic in the relation Castellbisbal-Vallirana. As it was explained in the firsts chapter of the analysis, both municipalities are placed in an important economic an industrial area, close to the Llobregat river and one of the most significant industrial centers of the region. This increase in the flux of vehicles could raise the level of traffic jam in the roads that connect both areas having negative effect during the rush hours of the days.

This also modifies the mobility patterns presented before. The interregional trips between The Vallès Occidental and The Baix Llobregat will increase as much as the intraregional mobility between the north and the centre of Baix Llobregat since the economic activity derivate from the action will attract some people displacements from the industrial centers in the north of the regions.

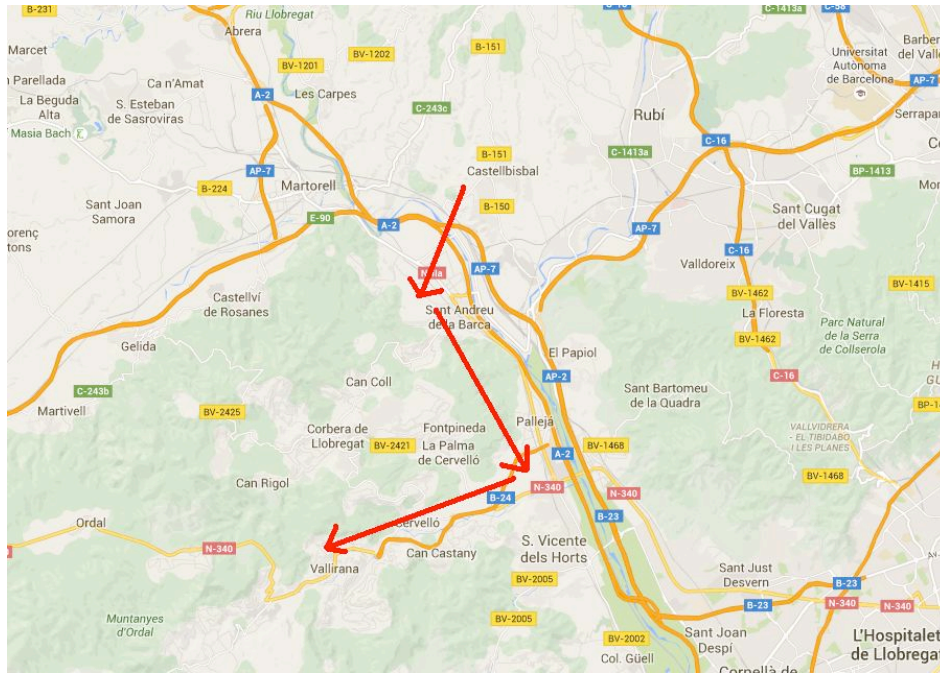


Figure 4.2. traffic flow generation from the project synergies.

This flux of daily trips will affect the habits of the people of the area and could change the behaviour of the transport infrastructures and some economic growth could appear in the area due to the increase in the mobility.

Furthermore, this relation will affect directly to the local productivity of the region since with the valorisation of the slag we are creating new activities and it could turn into the start-up of some companies attracted or generated by the demand of the different processes derivate from the valorisation.

The construction of the Castellbisbal and Gijón field test has supposed the valorisation of 750 tonnes of slag, which represents 1,000 tonnes of SFS-RAIL. The impact of this activity at local level is considerably high in both cases. The construction allows economic savings for the municipalities and helps to reduce the slag stock of ADEC GLOBAL in a smoother way. Although it represent a small percentage of the total annual productivity the results that could be obtained from its implementation will help to enhance the impact of the project, and if the feedback of the tests is positive enough, the transferability and replicability of the new product will be ensured along the whole territory. It is due to that fact that this action of the project is so important and the impact that will have in the potential increase of steel slag recycling and the development of the project is crucial.

4.1.3. Impact of the decrease of industrial waste

The valorisation of the slag proposed in the LIFE GAIN allows us to reduce the amount of industrial waste produced every year by the companies of the siderurgy sector. We are trying to extend the market of an industrial waste product by identifying a new field of valorisation, which shows good environmental and economic returns.

Given the huge production of this waste material, during the last few years, establishing a correct management of this kind of slag has been an important preoccupation of the researchers of the sector, who have been conducted to establish the potential use of slag in different activities. In Europe, the European association EUROSLAG, constituted by organizations and companies concerned with all aspects of manufacturing and utilization of ferrous slag products, deals with promotion of slag as a product, enables exchange of information and research as well as facilitates the interaction with governing bodies.

LIFE GAIN project will help to reduce the existing stock of the slag proposing a new use of it, increasing the amount of slag that will be valorised, decreasing the landfilled material and facilitating the management of the rest of waste

It's a fact that nowadays, Black slag is an abundant industrial waste product in the European Union; it is estimated that between 8 and 14 million tonnes of black slag are produced every year by the European steel producers.

In Spain this production is rather high in comparison with other countries of the continent. Spanish steelworks produce 15.5 million tonnes of crude steel, of which 75.2% correspond to EAF process according to the World Steel Association [24], generating 11.6 million tonnes of EAF steel. If we pay attention to the outputs of CELSA (the Spanish leading steel-producing company) and Badische Stahl-Engineering GmbH (BSE) (one of the world's most productive EAFS Mills)[25], the steel making process in EAF generates about 15% of slag per ton of steel. However, other references have been found indicating that the amount of slag, which is obtained by EAF process, is over 25% by weight of crude steel production [26].

Applying these ratios in the aforementioned EAF steel production, it is obtained that the volume slag production in Spain is between 1,743,750 and 2,906,250 million tonnes. As stated by ADEC GLOBAL, around 75% of the EAFS produced in the electric arc steel making process is black slag. Consequently, it is concluded that between 1,307,812 and 2,179,687 million tonnes of black slag are produced every year.

The LIFE GAIN project has a potential reduction of 216,000 tonnes of black slag per year, which is the actual maximum production of the ADEC GLOBAL valorisation plant, solving around the 16% of the Black slag management problems just for its railway use. This impact could be increased by the replication of the project and the adaptation of other valorisation plants around the country.

Based on its properties, slag is classified as non-hazardous waste and it can be disposed off to appropriate landfills. Disposal of such material requires large surfaces, has a great environmental impact on the landscape as well as on the vegetation and the fauna, and is rather expensive. Furthermore, there is always the risk that different components of slag might eluate.

The decrease of the industrial waste caused by this project will produce some environmental benefits at a local level, where the landfills are placed, since it will turn into less surface needed for the industrial waste landfilled that could represent the closure of some landfills or an increment of free surface for other materials that in another way should be sent to different places.

This minor level of activity in the landfills will also be a benefit for the population of the surrounding area. Some of the quality of life indicators, such as air quality or noise, will be improve for this people, and the traffic around the area will slightly decrease. If we could reach such a reduction of waste that will produce the closure of a landfill, a change in the demographic distribution of the territory may be possible in a short term since the opinion of the population about the surrounding area will change to a positive one.

It is also important the effect that the project will have on the landscape, vegetation and fauna. With the reduction of industrial waste all these aspects will be benefit from the improvement in the quality of life indicators, which will generate a better ecosystem and will transform the surrounding area in a more attractive zone to carry out new family and eco-friendly activities.

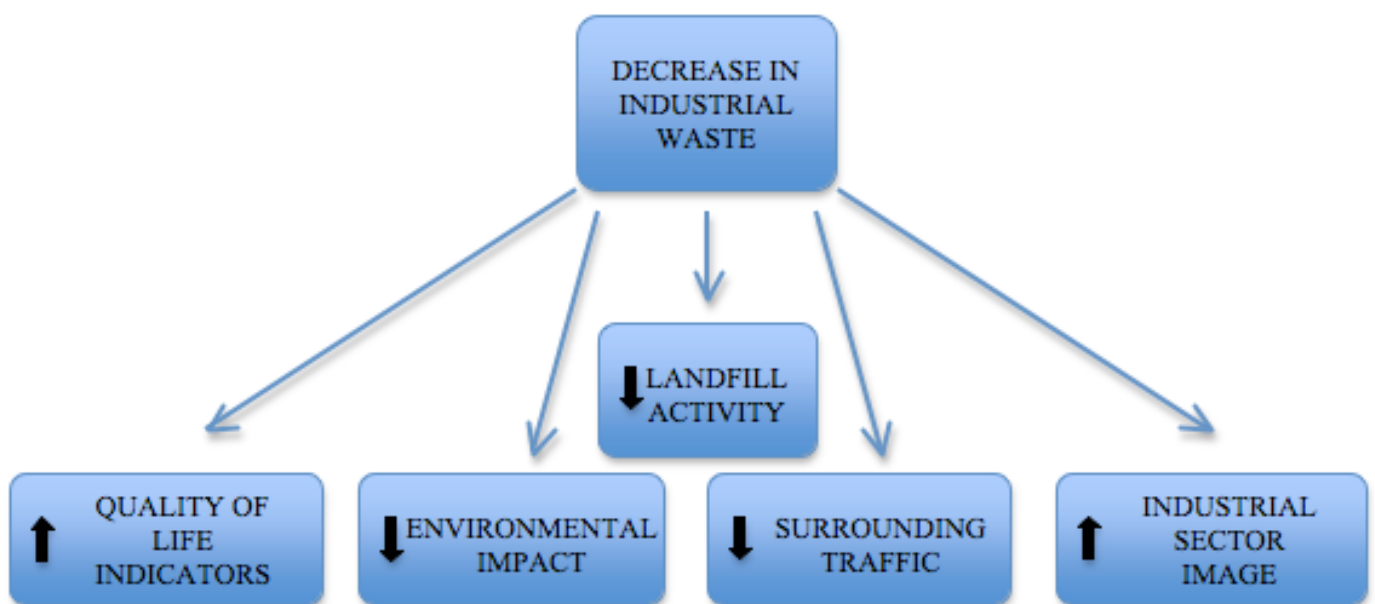


Figure 4.3. Effect of the decrease in industrial waste.

Another important aspect that the impact of the decrease of industrial waste will affect is the siderurgy sector. As it was aforementioned this industrial sector has an important weight in the GDP of the area studied, Asturias, Catalonia and specially El Baix Llobregat are ones of the main steel producers of the country and the development of such activity like the proposal of the project will improve the image of the siderurgy by the development of an eco-friendly business line, enhancing the sector since its waste product will be diminished and allowing to increase the sector productivity and its GDP's contribution.

Sometimes, the limited surface to stock the waste product conditions the productivity of the steelwork, so that the reduction in the stock of waste product of the steelworkers could help to increase its productivity and taking into account that this sector is one of the main users of the transport networks it will clearly affect the performance of the cargo distribution along the territory through railway or highway infrastructures.

Talking now about the field tests, both of them cause a reduction of 750 tonnes of slag in total. These tonnes were provided by CELSA and distributed along the sub-ballast and sub-grade layer in both cases. Of course it could seem not as big impact as the potential impact of the project, but we have to take into account that are just two sections of 100 m long to prove its mechanical properties, and if we extend this innovative method of construction to all the kilometres of track renovation or new construction (approximately 120 km/year according to the data obtained from a market study made by COMSA) the impact of the reduction of industrial waste will be significantly higher, reaching more than 500.000 tonnes of slag per year, that is almost the 50% of the total Spanish production.

4.1.4. Impact of the reduction of quarries activity

One of the clear impacts that the use of slag layers in railway foundations will have is the substitution of natural aggregates in railway track and its consequent reduction of the quarries activity that will turn into less number or/and volume of quarries needed in the territory.

The use of ferrous slag instead of natural rocks, such as limestone or granite, not only saves the energy that may be required to extract natural aggregates, but also eliminates the negative impacts associated with mining of aggregates in quarries such as:

- Disruption of the landscape
- Effects on biodiversity
- Emission of air contaminants

The transportation of natural aggregates to the rail works also has a great impact in terms of CO₂ emissions. The reason is that natural materials which can meet the requirements of railway regulations to be used as ballast, sub-ballast or sub-grade track foundation layers are often in short supply, because only natural aggregates from few quarries fulfil the technical requirements demanded. This situation results in scattered location of quarries relative to most work-sides (100 km approximately), which causes long transport distances.

The use of recycled aggregates made of black slag instead of natural rocks eliminates or reduces the aforementioned negative effects over the environment. To understand in which way the use of SFS-RAIL as sub-ballast or/and sub-grade layers materials contributes to environmental benefit and sustainability, a comparison between the production of slag and the extraction of natural aggregates from a quarry is done:

LIST OF ACTIVITIES	ACTIVITIES IN QUARIES	PRODUCTION OF SFS- RAIL
Deforestation (reduction in CO₂ emissions)	X	
Affectation to fauna	X	
Affectation to flora	X	
Hydrological impact on the zone	X	
Transport of black steel slag from furnaces to landfill	X	
Extraction of raw material	X	
Transport of raw material to rail site	X	X*

Pollution	X	
Noise	X	X**
Vibrations transmitted to the ground	X	X**
Use of water in a process of fabrication	X	X
CO₂ emissions	X	X*
Screening and crushing of material	X	X
Cooling of Black Steel Slag		X
X* Even though Noise/Vibration are produce as well as in the Valorisation Plant, the impact over the wildlife is lower than the quarries since are located in industrial areas.		
X** Usually the distance between the work site and quarries could reach up to 100 km since not all the quarries are authorised as railway suppliers, while the distance from work site to Recovery Plants are significantly shorter.		

Table 4.9. Comparison between natural aggregate solution and LIFE GAIN solution.

From the table above, where we can see the activities of both alternatives, we could deduce different qualitative effects. One of the main consequence of the production of SFS-RAIL is the reduction of the anthropomorphic impact on nature, the decrease in the quarries activity will have less impact in the landscape and the environment and the population of the surrounding area will be benefit from this fact increasing the social acceptance of the project.

A clear reduction in the deforestation and the impact on the vegetation and fauna will happen. The quarries need long surfaces to be placed and a high deforestation of natural area is associated to a quarry establishment, so that the less number or volume of such places will affect positively to the vegetation and fauna of the area having more space for natural activities. This minor activity will also affect to the local production since although the aggregates extraction is not an eco-friendly activity and it has some negative effect in the nature, is one of the main economic activities of the sector and the economy and productivity of the quarries surrounding area will be clearly affected reducing its volume of gains.

It is also important the reduction on the hydrological impact on the zone since the volume of water needed for the aggregate extraction is considerably higher than the volume used in the valorisation of black slag. The quality and amount of water in the nearby zone of the quarries will improve, if we bet for the alternative of the LIFE GAIN, being a benefit for the society.

As it was mentioned above, the frequency of the transport around the quarries will decrease being a benefit for the population since the noise vibrations and pollution of the zone will improve, deriving in a better quality of life indicators. In the same way, the length of the transport of railway aggregate to the work site will be reduced from 100 km to 50km approximately because of the higher number of valorisation plants distributed along the whole territory in comparison with the number of quarry with ballast supply allowed. A reduction of 6.03 tons of CO₂ have been reduced with the field test activity, but a potential reduction of 200,000 tons per year is possible to be achieve in the next years just in terms of aggregates transport.

Another significant savings produced by the LIFE GAIN project is in terms of energy consumption during the production process of the SFS-RAIL and the aggregates

extraction. It is an important aspect considering that the steel production is one of the processes with the highest energy consumption in Spain, and the use of a waste product from there will help us to obtain energy savings in other production processes. With the field test construction more than 190 million kwh are saved, and a potential savings of 65,909 million Kwh per year are estimated during the next years after the project implementations.

Once analysed the different possible impact of this action it's easy to conclude that substitution of such non eco-friendly activity like aggregate extraction will supposed an immense benefit for the society and environment, and although the local productivity around the quarries will be decrease reducing the economic activities of the zone, the new production of the SFS-RAIL will recover the productivity of the industrial sector, which will be slightly modified, enhancing the siderurgy sector and reducing the contribution of the aggregates extraction.

4.1.5. Impact induced by the increase in jobs

The SFS-RAIL will have a high transferability and replication potential. The applicability of the results of this project in the European market is feasible thanks to the following two factors:

- There is a huge European stock of SFS. In addition, it is an issue of concern for steel furnaces because of the environmental and economic impacts caused by the disposal of this waste product.
- The territorial distribution of steel furnaces in Europe appears to be quite homogeneous and dense. This is an indispensable factor to guarantee the minimisation of transport environmental impacts and costs, making SFS-RAIL even more competitive than natural aggregates.



Figure 4.4. Location steel mills in Europe.

If this expected replication is carried out in other European countries, new employment will be created in order to satisfy the demand of human resources to develop each of the implementation phases: adaptation of the existing slag valorisation plants, manufacture of the raw material, SFS-RAIL stock management, transportation, rail track construction etcetera.

In order to compute the number of Jobs generated for the Project we have taken into account the turnover and the employers of ADEC GLOBAL as an example of a valorisation plant. This company has a turnover of three million euros per year and gives employ to 50 specialized workers that carry out the production of 216,000 tonnes.

The construction of the field test will not suppose a significant growth of the employers of the company, it could be carried out practically without an increase in the numbers of employers, since just 1,000 tonnes have been valorised (approximately the material valorised by ADEC GLOBAL in one day), and we can get this amount easily from the slag stock or slag daily production. With regards to the construction of the different layers of the field test and the installation of the equipment needed for the monitoring some temporary new jobs could be created depending on the available workers of the company in the moment to carry out the activity.

On the other hand, to cope with the potential production of the LIFE GAIN project, the valorisation of 116,640 tonnes of slag will suppose an increment of 777,600 € in the

turnover. Such increment like this will turn into the engagement of 13 new specialized workers for the valorization plant and the generation of 20 indirect jobs. In the LIFE GAIN project the first company that will hire these employers in the next years will be ADEC GLOBAL in order to keep the production levels needed to satisfy the new demand generated.

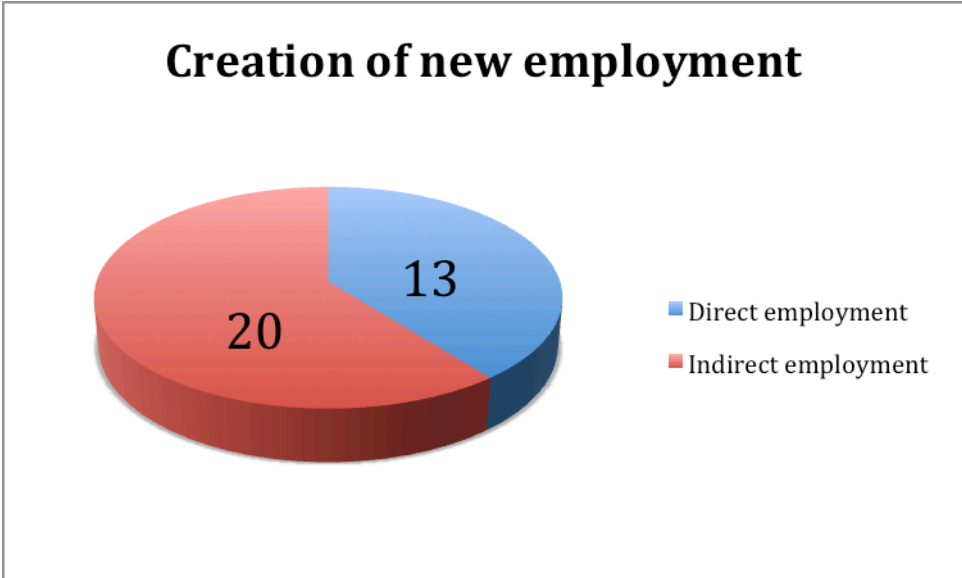


Figure 4.5 New employment created due to ADEC GLOBAL activity.

Taking into account the possible replication and transferability of the project results, more than one hundred valorization plants could be adapted around the whole Europe during the next years after the implementation of the project. This fact will suppose that more than 1,300 of direct employments and 2,008 of indirect employments will be generated due to the LIFE GAIN project.

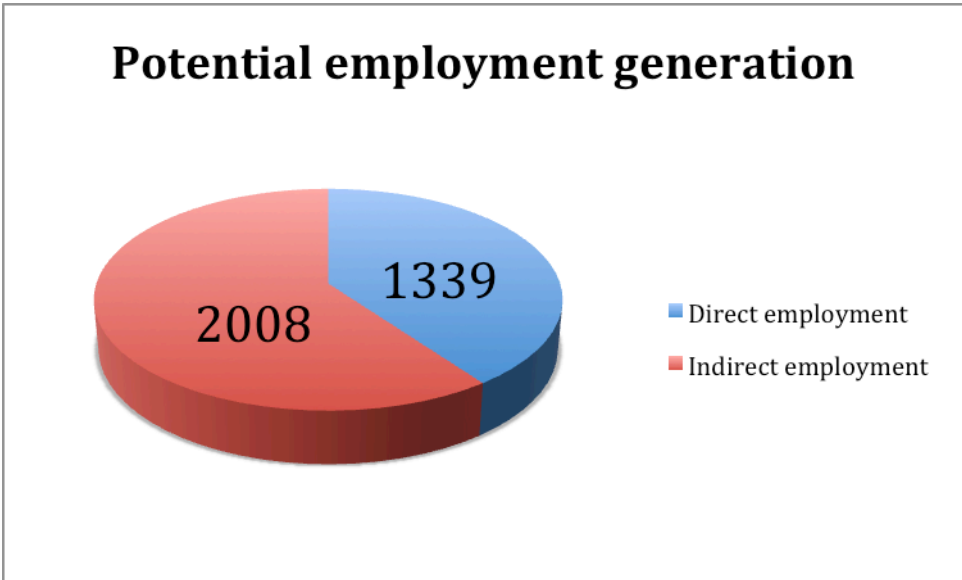


Figure 4.6 Potential employs generated by the replication of the project.

This increment in the jobs of the industry sector will reduce the number of non-employed population during the next years. The negative trend of the active population described in the previous chapters could be an inconvenient to select qualified people

for this jobs since the reduction of the population between 15 and 65 will be significant and it does not seems that this trend is going to be reverted soon.

The initial jobs created by the project will be in the nearby area of the valorisation plant (Metropolitan area of Barcelona). This is a region with high density of population that could satisfy the new demand of workers, and in this zone the siderurgy sector is well develop so that qualified people will be easily found.

The higher productive activity and the jobs created could suppose the establishment, in the area, of new companies of the siderurgy sector or that carry out processes needed for the siderurgy or valorisation production such as raw material obtainment or machinery design. This fact will be in consonance with the recent trends analysed in the region of Baix Llobregat, where we have seen in the Figure 3.24 how the growth of the new companies established in the north and centre of the region has significantly increase in the last years, enhancing the industrial sector of the area and promoting the economic activity and its GDP contribution.

The possible jobs created for the construction of the field test sections may have a temporary duration and it will not has an important effect in the distribution of the population of Gijon and the metropolitan area of Barcelona. Otherwise, the future increment of jobs because of the development and replication of the project activities could be one of the main factors that causes a change in the demographic distribution in the influence zone, attracting population from the south of the Baix Llobregat, Barcelona and North of Vallès Occidental to the influence zone of the LIFE GAIN project. This fact will also help to enhance more the last trends in the population distribution of the area, where the higher growth of inhabitants have been registered in the North and Centre of Baix Llobregat.

An increment in the mobility of the region will be induced for the growth of the jobs and the economic activity. The intraregional and interregional relation will be higher attracting people from different places and sector since the economic activity generated will be in the siderurgy sector but during the next years after the implementation of the project, the enhancing of the industrial activity of the zone will affect to different industrial sectors. This growth in the mobility will affect the infrastructures of the surrounding area, which in a short term it could manage the increment of the traffic, but depending on the replication and the transferability of the project results, in a medium term, a restructuration of the transport network could be necessary.

The reduction of the unemployed population will change the opinion of the inhabitants and increase the social acceptance of the project. Although a higher number of qualified workers of the sector will be necessary, the development of siderurgy sector is one of the most positive aspects of the project according to the survey done to the affected population.

5. CONCLUSIONS

The main conclusions derived from the research undergone are summarised below:

- We can affirm after the analysis of the social and economic impacts of the project that the main objective, which is to extend the market of an industrial waste product by identifying a new field of valorisation, is well accepted for the society and it is feasible in economic terms, taking into account that the general impacts of the project have positive effects in the different areas studied.
- Although nowadays the main application of SFS aggregates is road construction, the use proposed in this project could reach a high percentage of the market in the short term due to the improvement of the railway transport during the last years and the incredible good mechanical properties that this valorised material gives to the track when it is applied in the sub-ballast and sub-grade layers.
- With the use of SFS-RAIL we obtain environmental benefits that decrease the global warming effects. The impact of this phenomenon is reduced by a 30% in terms of CO₂ emissions.
- The location of the field tests were correctly chosen since the tests are placed in important industrial areas, where the siderurgy sector is one of the main participants in the GDP of the area. In the case of the Catalonia, it is near the slag valorisation plant in order to minimize the transport costs and emissions, hence reducing its negative impact.
- The subdivisions of the Baix Llobregat made for the study of the influence zone allow us to have a better characterisation of the region in terms of mobility, distribution of the population and population growth, which finally help us to identify the different possible effects that the LIFE GAIN project has on the territory.
- From the analysis of the population we can conclude that the influence zone of the project is an area that is suffering an important demographic development in the last years and a significant amount of population will be directly affected by the project consequences.
- The population of the Catalan area affected is younger than in the rest of Catalonia, so that the active population is higher and we could find qualified workers easily to satisfy the demand generated by the increment of jobs.
- The differences in the distribution of the population in the territory will influence in a significant way the mobility of the people since a big amount of trips are generated every day due to the people who have to leave their municipality to go to their job placed in a nearby city. This high mobility could be a major drawback when the increase of mobility generated by the project activities appears in the territory, since the transport infrastructure must hold all the traffic flow.

- The projection of the population of Gijón is not as good as the Catalan one to satisfy the demand of workers since the aging process will be higher during the next years.
- The two analysed areas, Gijón and Baix Llobregat-Vallès Occidental, have a significant contribution in the industrial productive structure of its respective regions. Moreover, the siderurgy is one of the most developed industrial sectors, so that the impacts of the activities that improve the productivity in this industrial area will be considerable higher in comparison with the application of these actions in other sectors, which have not such volume of production and GDP participation. The construction of the field tests and the valorisation of the ADEC GLOBAL plant will contribute to impulse the economy of the area having positive effects and, without doubt, are actions in line with the development trends of the area.
- With the mobility analysis we have observed the capacity that the North industrial centers of the Baix Llobregat region have to attract population from the South of the region and the Vallès Occidental region, so that the adaptation of the valorisation plant and its growth in productivity terms during the next years as a result of the economic activity generated by the project could help to enhance this effect, attracting more people from other zones and promoting an homogenization of the industrial activity of the whole region, whereas nowadays the South part is predominant.
- The project has a high social acceptance and most people think that this project should be carried out for its environmental, social and economic benefits. The population see the slag valorisation as an important activity for the development of the industrial sector and bet for the replication and transferability of the project technology and results around the whole Europe.
- The Black Slag is one of the main industrial waste in Europe and actually exists some storage problems of this material, so that is important to develop new technics that help us to reduce and manage this amount of waste to minimize the environmental impact of the steel production.
- It is important to distinguish between the steel recycling, which is being carried out since a long time ago, and the recycling or valorisation of the waste materials from the steel production (slag), which makes interesting the present analysis.
- From the impact of the investment and the computation of the economic indicators we could deduce that the profitability of the project is high enough to carry out the activities and develop the technology proposed in the LIFE GAIN. The NPV of the project reach the 264,277 € according to the analysis done for the next five years after the project's implementation, this indicates that the project will generate gains above the profitability required (5%). In the same way, the low initial investment needed for the adaptation of the valorisation plant, and the economic benefits from the SFS-RAIL selling, gives us an IRR of

70%, which shows the incredible profitability of the project that present a payback period of just 1.5 years.

- Considering the potential impact of the project in the next years, the social benefit obtained in economic terms will be 772,233 € per year, while the project will produce an environmental savings of 471,883 tonnes of CO₂ emitted.
- Likewise, considering just the impact of the field tests construction, the local social benefit of the project in economic terms will be 4,965 € during the first year, while the environmental saving raise up to 3,034 tonnes of CO₂ emitted that represents a local economic savings of 17,234 €.
- The valorisation of the slag is a profitable activity for ADEC GLOBAL, who obtains significant benefits during the last years, and the relation with CELSA due to this process will create some synergies between the companies that will affect to the mobility patterns of the area and will produce some economic growth in the influence area. On the other hand, the amount of slag valorised for the field test will not have such an important impact but will produce some economic savings at a local scale.
- The potential impact of the LIFE GAIN activities in terms of reduction of industrial waste is 216,000 tonnes, which will suppose that all the production of the plant is used for SFS-RAIL. In this way, the project allow us to manage more than the 16% of the total Spanish annual slag production, solving a considerable percentage of the industrial waste management problem. This impact could be increased with the transferability of the project technology to adapt other valorisation plants of the country.
- The quality of life indicators of the population will be improved because of the reduction in the industrial waste and the reduction in the quarries activity.
- Some important savings in terms of tonnes of CO₂ emitted will be derived from the reduction of the natural aggregate extraction and the shorter transport distances to the work-sites.
- Although the temporary duration or the possibility of zero employments created for the field tests construction, the potential production and the high transferability and replication of the results will create new employment in order to satisfy the demand of human resources to develop each of the implementation phases.
- The jobs created by the project activity will reduce the number of unemployed population. In addition, it will affect to the demographic distribution in the next years and the mobility induced for the job creation will increase the intraregional and interregional daily trips.

For all these reasons we can finally ensure the high importance of the development of the LIFE GAIN project at a local and global scale, since the society, the economy and the environment will be clearly benefited from it.

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